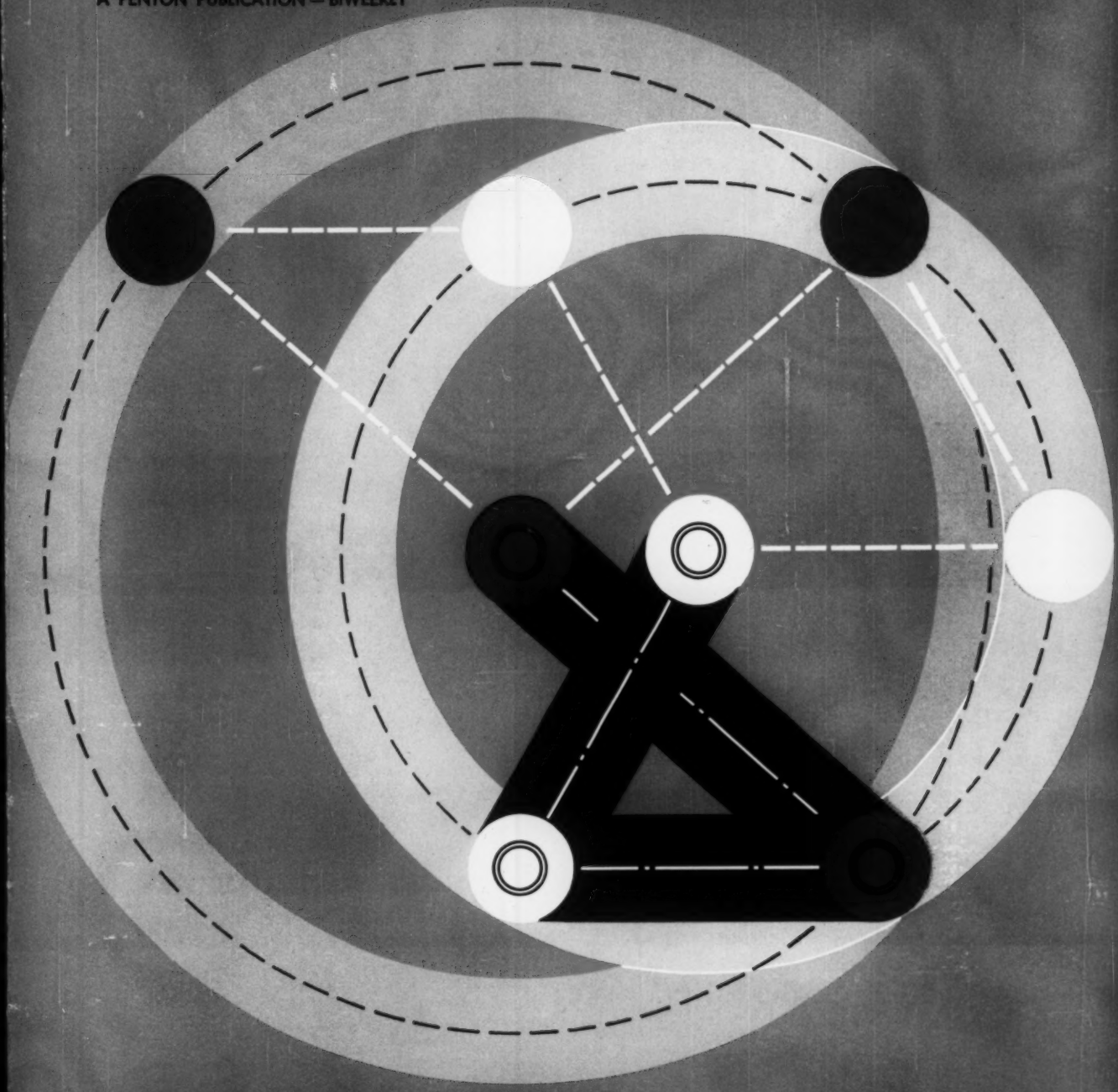
JUNE 26, 1958

MACHINE DESIGN

A PENTON PUBLICATION — BIWEEKLY



Drag-Link Mechanisms

Contents, Page 3

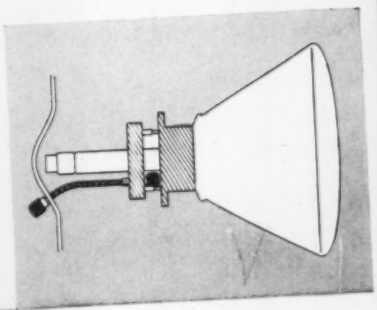
S. Silbhite

Flexible Shafts Simplify Product Design

The designer of this TV set used S. S. WHITE Flexible Shafts to avoid the many restrictions which a rigid connection would have imposed on his design.

Whether your product is in the design stage . . . or in full production, S. S. WHITE Flexible Shafts may be the simple, economical road to improvement. Power sources, driven members, controlled parts and their controls can be positioned to better advantage. Alignment problems, costly methods of connection and adapting can be eliminated. The number of parts required for control and power drive can be reduced, thus reducing assembly time and cost.

Our engineers will be glad to give you their help in selecting and applying the flexible shaft that will do the best job for you. For full information, just write to



S. Silbhite

FIRST NAME IN FLEXIBLE SHAFTS

USEFUL DATA on how to select and apply flexible shafts! Write for Bulletin 5601.

S. S. White Industrial Division, Dept. 4, 10 East 40th St., New York 16, N. Y. Western Office: 1839 West Pico Blvd., Los Angeles 6, Calif.

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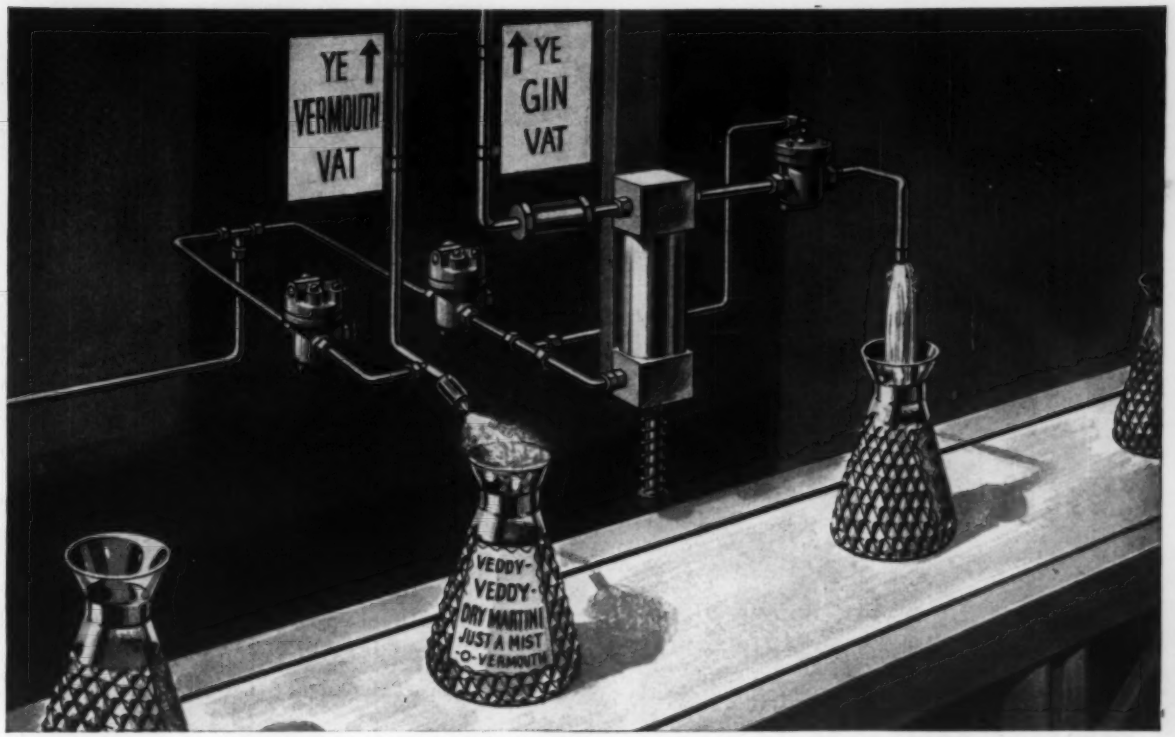


What? Air Automates the Extra, Extra-Dry Martini!

The ready mixed Martini may never come to this but . . .

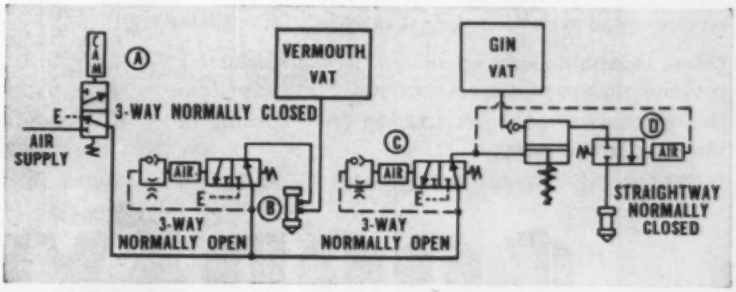
"Don't bruise the Vermouth!" Maybe you subscribe to the idea of only a fog of Vermouth or maybe you like yours four-to-one. But, if it came to bottling this vogueish mixture, the circuit here could certainly do it. Meanwhile it gives us a fanciful way to show you how you can easily create an all air circuit that does a continuous sequence of timed operations by using valves that can be both operated and sequenced by air. Every time the conveyor stops, it triggers the circuit.

Triggering one operation with another and timing the operating periods—all with air—may save the day for you.

The same air involved in the main operation can also pilot these valves. What's more these valves can be preset to wait out a time delay before operating, or operate for a self-measured time. Using them you can create unlimited all-air automation systems which could just turn the trick where you wish to avoid electricity, or want to stick with just one power medium.

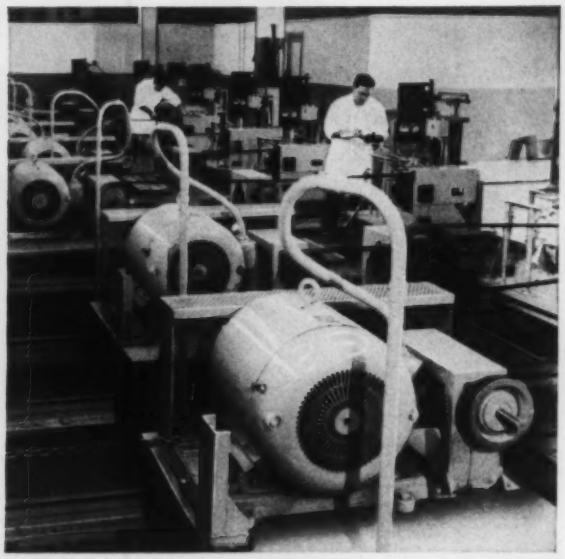
SEQUENCE OF OPERATION

1. Conveyor indexes, opening cam valve (A). This introduces air to valves (B) and (C) which begin timing in. Vermouth is atomized by Vermouth nozzle, cylinder expels a measured amount of gin through master valve (D) which has been opened by air from the outlet of valve (C).
2. Valves (B) and (C) time out and close, stopping liquid flow.
3. Conveyor indexes again.



ROSS OPERATING VALVE CO. 109 East Golden Gate • Detroit 3, Michigan

Why V-Belts with the Green Seal meet every test



Nearly one-third of all electric power used at the Goodyear V-Belt plant goes into testing, checking and development operations. These giant dynamometers, for example, test larger belts in all speed ranges and with various pulley diameters—with belt loads from zero to 100 h.p. The effects of reverse bending, various placements of idlers and high or low tension are also checked.

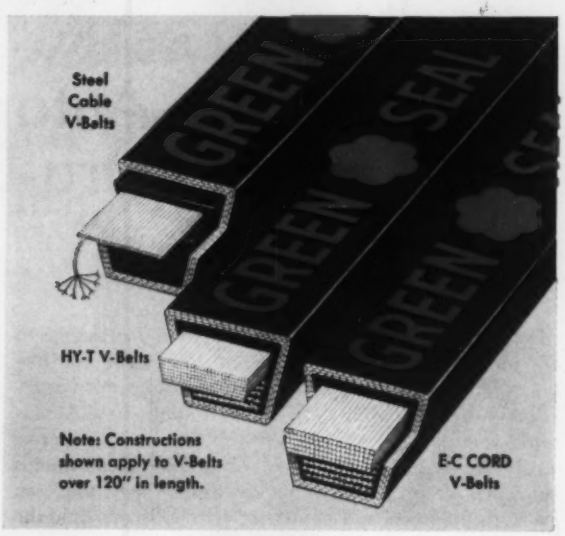
Dimensional stability! Belts are even test-run in closed, high-temperature ovens—to verify that their 3-T (Triple-Tempered) construction remains dimensionally stable under extreme operating conditions.

Perfectly matched sets! Belts are carefully measured on ultra-precision machines – then carefully coded to guard against "loafers" – or belts that overwork.

High strength, low stretch! Belts are subjected to "breaking point" tensile-strength tests in the Goodyear laboratories – to insure long, trouble-free service on your drives.

Maximum resistance to shock-loads! Belts are "tortured" on special machines that simulate the severest service – your protection against early belt failure.

Clean, smooth-running operation! Special nondusting rubber cover compounds are continually tested for friction balance – to give you freedom from sticking or grabbing in the grooves.



To pay off in—

Maximum trouble-free horsepower hours at minimum cost. That makes it a real gamble to settle for anything less than V-Belts with the Green Seal. See your Goodyear Distributor – or write Goodyear, Industrial Products Division, Lincoln 2, Nebraska, or Akron 16, Ohio.

DIMENSIONALLY STABLE V-BELTS with the GREEN SEAL by

GOODYEAR

60 YEARS

THE GREATEST NAME IN RUBBER

Green Seal, E-C Cord, Hy-T – T. M.'s The Goodyear Tire & Rubber Company, Akron, Ohio

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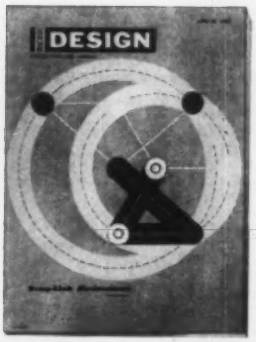

Front Cover: A drag link or double-crank mechanism is essentially a "motion transformer," as shown by artist George Farnsworth. Featured article by Kurt Hain is on Page 104.

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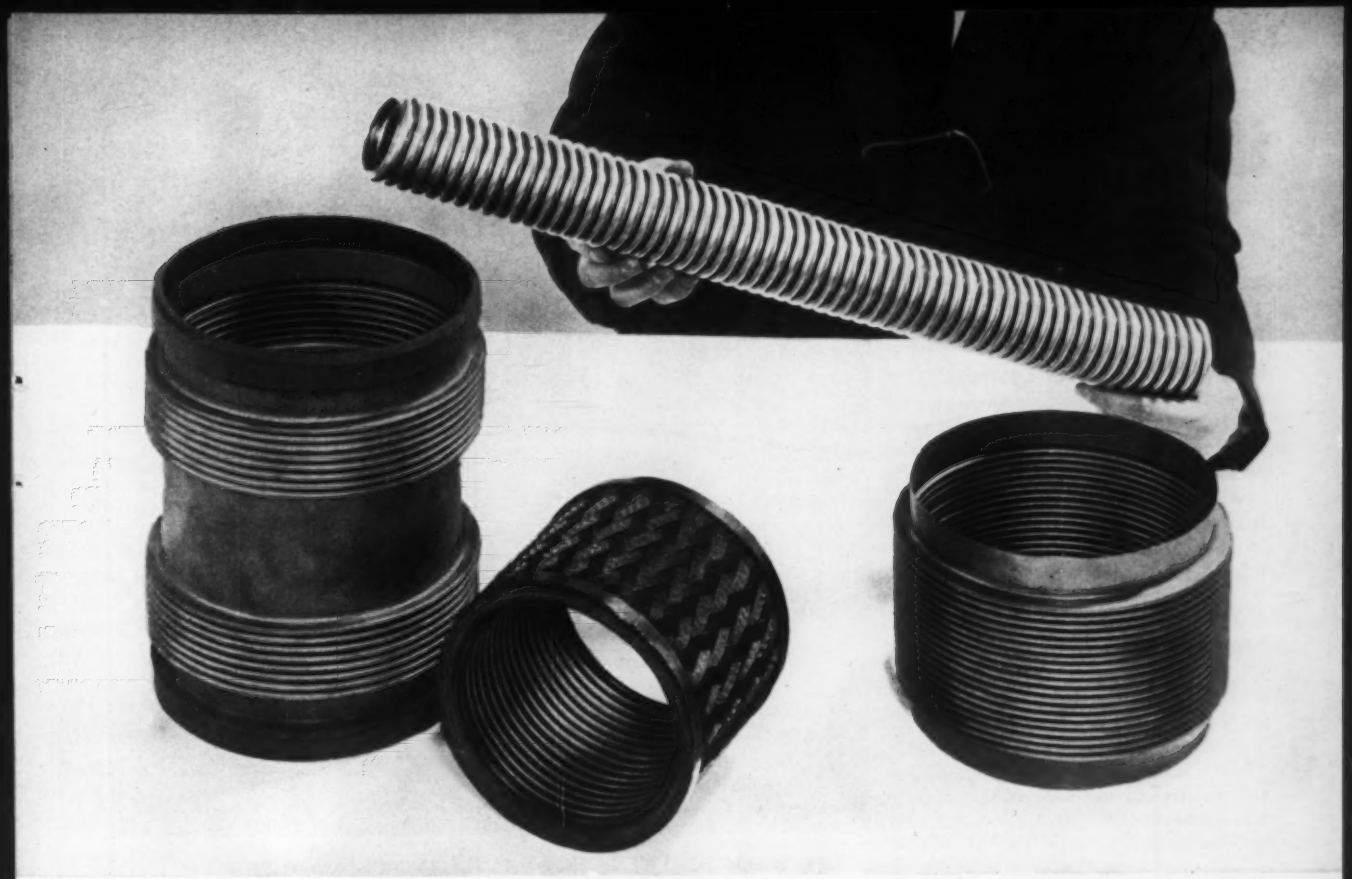

FLEXIBLE CONNECTORS, in a variety of sizes, constructions, materials, are designed to meet many working conditions. Our sales representatives in cooperation with our engineering design service will be glad to be of assistance.

BIG space-age problems get BIG flexible metal tube answers

Large-diameter flexible metal connectors in stainless steel and other alloys—to handle expansion and contraction, wide range of temperatures, corrosive fluids, high pressures, and vibration.

Jet engines, modern chemical plants, rockets, atomic energy plants have created a new technology that calls for new products. The American Metal Hose Division of The American Brass Company is constantly working with design engineers on special flexible connector assemblies to meet new problems.

Equipped to work in stainless steel, Monel, and aluminum as well as in other alloy steels and copper alloys, these Anaconda specialists welcome the opportunity to help you get the flexible metal hose you need to meet your problems of expansion and contraction, movement, vibration, corrosion, pressures, and temperatures.

FREE TECHNICAL SERVICE. For engineering assistance on special products—or for a free copy of our General Catalog showing the full line of standard American Flexible Hose and Tubing products—write: The American Metal Hose Division, The American Brass Company, Waterbury 20, Connecticut.

58168

WHEREVER CONNECTORS MUST MOVE

AMERICAN
FLEXIBLE METAL HOSE AND TUBING

an

ANACONDA®

product

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THE AMERICAN BRASS COMPANY
American Metal Hose Division, Waterbury 20, Conn. MD

Please send me your free, 60-page General Catalog containing basic information on all types of metal hose and tubing, fittings, etc.

NAME & TITLE .....

ADDRESS .....

COMPANY .....

CITY, ZONE, STATE .....
(PLEASE PRINT OR TYPE)

ENGINEERING NEWS

Precision-Form Tiny Cores In High-Temp Metal Castings

LOUISVILLE—A method for precision-forming tiny cores in high-temperature metal castings has been developed by Corhart Refractories Co. Inc., a subsidiary of Corning Glass Works. High-accuracy Vycor glass tubing with an outside diameter as small as 0.020 in. is fixed to the inside of a precision casting mold before pouring. The tiny sections of 96 per cent silica glass tubing can withstand casting temperatures over 3000 F.

After the metal has cooled, the glass tubing can be readily leached by molten caustic without harm to the casting. This leaves a core of precise measurements, requiring no machining.

One application for the tubing is in casting turbine blades for high-temperature jet engines. The cores permit passage of a coolant through the blade and effectively raise the service temperature of the engine.

FIRST WITH A FLYING-BOAT HULL, Sikorsky's new turbine-powered amphibious helicopter was designed by blending a new airframe and power-plant with mechanical components of Sikorsky's time-tested S-55 model. This permits modification of all existing S-55's to turbine-amphibians, at less than new amphibian cost. The new S-62 carries 10 to 12 passengers at a cruising speed of 105 mph. It can fly into the heart of metropolitan areas with added convenience and safety by following waterways that flow through or around almost every major city.

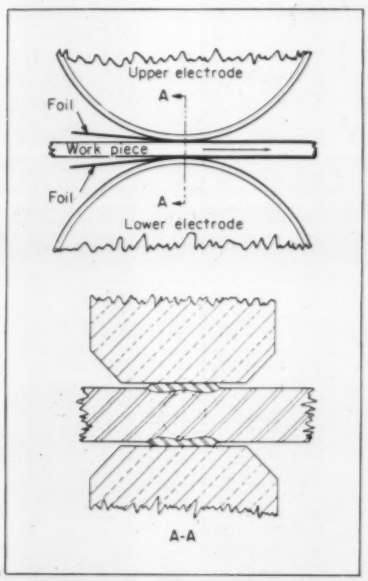
Welding Machine Uses Foil Strip

Dense Seam Welder Swiftly Joins Steels

CINCINNATI—A foil butt-seam welding process, used in Europe for several years, makes nonoverlapping seam welds of dense structure at extremely high speeds. The process has been licensed to Precision Welder & Flexopress Corp., Cincinnati, and is used in their new machines. They report welding 0.078 in. stock at 3 to 24 fpm.

The process is said to use less heat and pressure than mash welding, and therefore to require less power and produce less warping of sheets. It can be used for mild steel, low-alloy, high-carbon, and stainless steels.

Typical applications include: railroad car industry (welding sides and roofs), automotive industry (welding fenders, mufflers, and gasoline tanks), appliance industry (welding washing machine tubs, dishwashers, sinks, and refrigerators), steel mill industry (joining ends of coils), and various applications in aircraft and other industries (often in place of seam, flash, or fusion welding).



European process involves introducing a thin strip of foil on each side of the butt seam to be welded. The foil acts as a bridge to distribute welding current to both sheets, and prevents too-quick removal of heat from the joint area. Foil strip increases electrical resistance and helps contain the molten weld nugget while it grows in area and cools. Sheets are usually clamped. Sometimes the foil is spot-tack welded at lower heat before being seam welded.

... Fluid Power news

REPORT No. 11,702

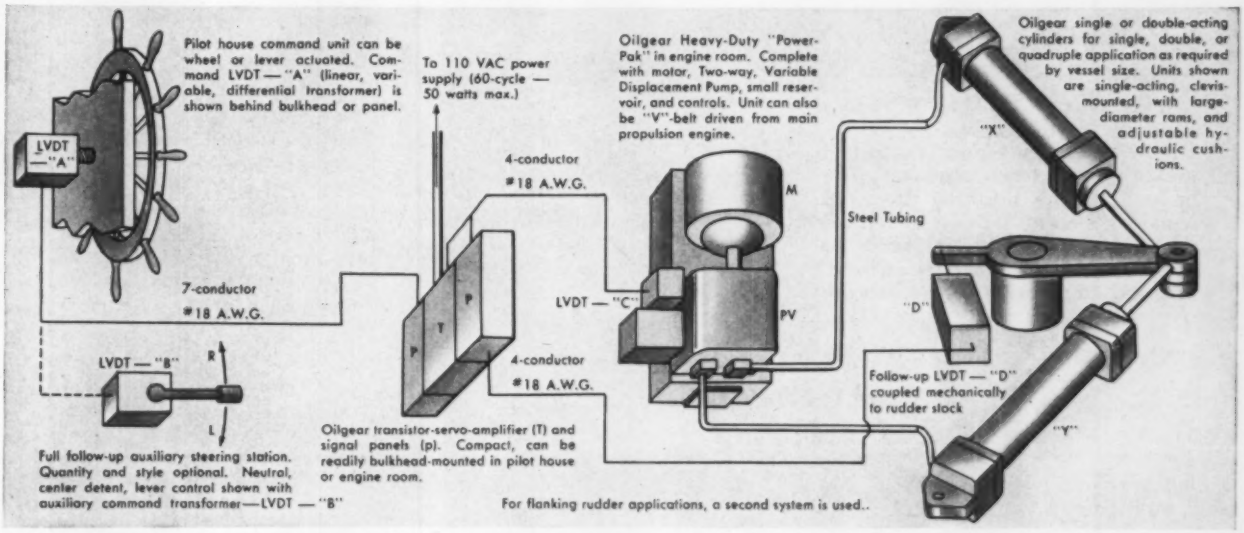
NEW MARINE STEERING CONCEPT

From Oilgear Application-Engineering Files

HOW OILGEAR APPLICATION-ENGINEERING AIDED CREATION OF MODERN MARINE STEERING GEAR

CUSTOMER: *A long-established Marine Engineering Company (name on request)*

DATA: This company's technical staff concluded that marine steering gear could be modernized instead of merely being made larger and heavier. A design program to incorporate new electric and hydraulic developments had the following basic objectives. 1: Extreme flexibility for normal application on all vessels requiring power steering. 2: New economy in system weight, size, and installed cost. 3: Simplicity, accuracy, reliability. 4: Full follow-up pilot house and auxiliary station control of rudder movement, speed, position. 5: Eliminate make-and-break, or sliding electrical contacts, relays, vacuum tubes, solenoid valves, heavy shafting, gears, racks, and linkage in the control system. Smooth, positively indexed, rate responsive, stepless rudder movement control that is noise, shock, vibration, and pulsation-free. 7: Compatible with gyro-compass, automatic steering.


Pilot house command unit can be wheel or lever actuated. Command LVDT — "A" (linear, variable, differential transformer) is shown behind bulkhead or panel.
LVDT — "A"
To 110 VAC power supply (60-cycle — 50 watts max.)
Oilgear Heavy-Duty "Power-Pak" in engine room. Complete with motor, Two-way, Variable Displacement Pump, small reservoir, and controls. Unit can also be "V"-belt driven from main propulsion engine.
Oilgear single or double-acting cylinders for single, double, or quadruple application as required by vessel size. Units shown are single-acting, clevis-mounted, with large-diameter rams, and adjustable hydraulic cushions.
4-conductor #18 A.W.G.
7-conductor #18 A.W.G.
4-conductor #18 A.W.G.
LVDT — "B"
R
L
LVDT — "C"
M
PV
P
T
P
"X"
"D"
"Y"
Steel Tubing
Follow-up LVDT — "D" coupled mechanically to rudder stock
Full follow-up auxiliary steering station. Quantity and style optional. Neutral, center detent, lever control shown with auxiliary command transformer—LVDT — "B"
Oilgear transistor-servo-amplifier (T) and signal panels (p). Compact, can be readily bulkhead-mounted in pilot house or engine room.
For flanking rudder applications, a second system is used..

SOLUTION: Above schematic symbolizes an Oilgear Fluid Powered, electrically controlled, marine steering system utilizing the newest electric-hydraulic developments. *Actual installations using this new Oilgear "electro-feedback-hydraulic-servo-control system" have exceeded ALL of the customer's original engineering objectives* . . . proof of Oilgear's cooperation and teamwork to help solve design engineer's problems. Oilgear Heavy-Duty "Power-Paks" are complete, ready-to-install power units in sizes and types to meet every marine need. No auxiliary valves, pumps, controls, reservoirs, or "plumbing" are required. Oilgear "Custom-Quality" single and double-acting cylinders can furnish the "muscle" to control any type vessel. Oilgear ServoControl Division's rugged, compact transistor-servo-amplifier and control system is further proof of Oilgear progressive, pioneering, engineering service. Connections between the amplifier and signal generators can be made by any competent electrician.

In every industry, manufacturers and users recognize and trust the name "Oilgear" for dependable, lowest-cost-per-year operation.

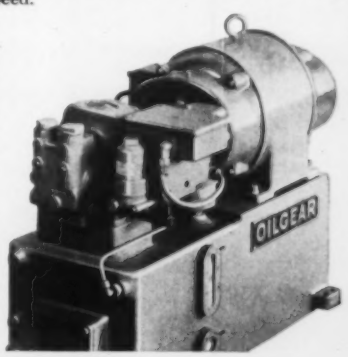
For similar practical solutions to YOUR linear or rotary Controlled-Motion problems, call the factory-trained Oilgear Application-Engineer in your vicinity. Or write, stating your specific requirements, directly to . . .

THE OILGEAR COMPANY

Application-Engineered Controlled Motion Systems

1568 WEST PIERCE STREET • MILWAUKEE 4, WISCONSIN

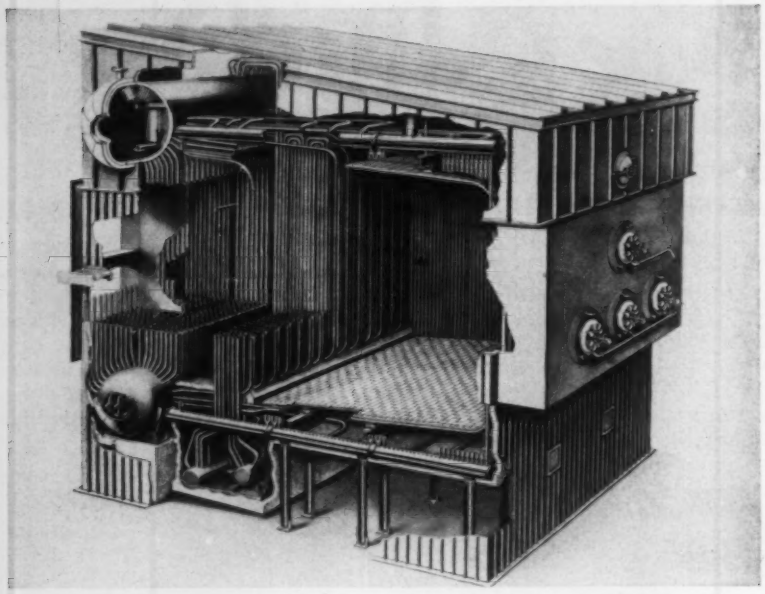
OPERATION: LVDT units (A, B, C, D) are actually coils with a core or slug moved axially in the coil airgap. When core is at central position there is a "null" signal. Maximum signal is emitted at maximum limits of travel — either "in" or "out." Movement of wheel or steering lever displaces core of command LVDT (A or B), producing a signal that is compared in transistor amplifier (T) with the signal from rudder stock coupled LVDT (D). Resulting difference between these two signals is called the "error" signal — built up to usable current strength by amplifier (T). Amplified signal is applied to an AC torque motor on Oilgear Two-way, Variable Displacement Pump (PV), imparting movement in amount and direction as ordered to a hydraulic servo valve — stroking pump (PV) to supply ordered direction and volume to rudder actuating cylinders (X, Y). As rudder moves, coupled LVDT (D) is displaced to reduce error signal to zero — at which point the cycle is complete. During this cycle, pump LVDT (C) has also been sending its signal to the amplifier for comparison, insuring that pump output is always under error signal control. Rapid motion of the command wheel or lever generates a large error signal, resulting in full rudder speed. Similarly, a slow command movement results in a slow rudder speed.



RIGHT: Oilgear Size 3, Heavy-Duty "Power-Pak" with Two-way, Variable Displacement Pump, motor, reservoir and controls . . . "as shipped," ready for installation with an "electro-feedback" system described above. This unit is now in use on a new 144' x 55' x 5' draft ferry boat of 483-ton displacement.

Similar Oilgear Systems are being used to control motion in all industry.

Please direct inquiries to advertiser, mentioning MACHINE DESIGN



OIL OR GAS, or a combination of both, can be used as fuel in this pressurized-furnace steam generator. The unit is designed for power, process, or heating loads requiring steam capacities up to 400,000 lb per hour. Integral combustion air duct at top of unit conserves space. At left center is the drainable superheater, which permits the draining of water after a boiler shutdown. Burners at extreme right are centralized for easy observation and adjustment in new Babcock & Wilcox Co. unit.

HIGHWAY PROFILES will be measured for variances of 1/32 in. by this well-instrumented mobile "profilometer." Sixteen wheels at front and rear, plus recording wheels under center of the truck, will graphically record mile-per-mile pavement irregularities. Each road slab is also photographed for crack patterns. After two passes—before and after a variety of weather and traffic conditions—pictures and graphs will be compared. Results will determine importance of soil condition, drainage, and construction as compared to the effect of traffic loads. Univ. of Michigan developed the instrumentation for Michigan State Highway Dept.

Topics

Suddenly it's 1901 again in the automobile market. A replica of the Oldsmobile of that year is in production, with 5000 scheduled for the next two years. Working from plans supplied by General Motors, American Air Products Corp., Ft. Lauderdale, Fla., is building these sporty antiques to sell for about $1200. Gas consumption of the 93-in. long, open-air, tiller-steered contrivance is low (65 miles per gallon); top speed is 35 mph. Radical substitutions are sealed-beam for kerosine headlamps and an electric starter for a crank.

For those who prefer a smaller car, Starts Mfg. Co. in Ft. Lauderdale is making a two-thirds size version of the 1901 Olds. It lacks the forward look, but can claim strictly forward motion: It has no backup gear.

• • •

New twist for bread dough is provided by a machine which, in one installation, increased production of twisted loaves by 30 per cent. A molder-twister-panner developed by Baker-Perkins mechanically duplicates hand twisting and produces a loaf equal in texture, softness, taste, and keeping quality to one made by human hands.

• • •

Traffic tremors, recorded on seismographs, could be used in measuring and recording traffic density and peak periods. Proponent of this idea is the Rev. J. Joseph Lynch, director of the Fordham University seismic station, who points out that each motor vehicle in motion affects the earth as if it were a tiny earthquake.

• • •

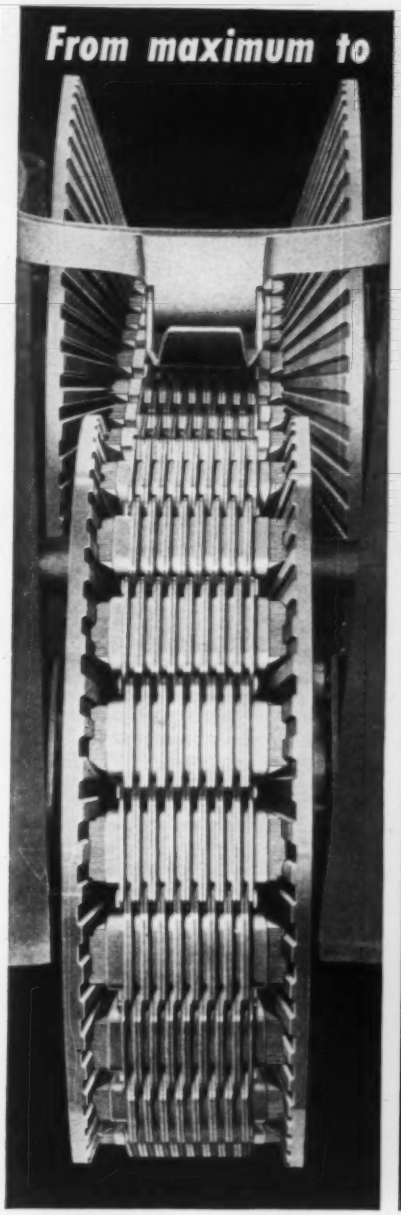
Slot machine for eggheads dispenses a quiz game. Questions and multiple-choice answers appear on the face of a cabinet and the player indicates the number of the answer he thinks is correct. A player rating high in accuracy and promptness wins a free game.

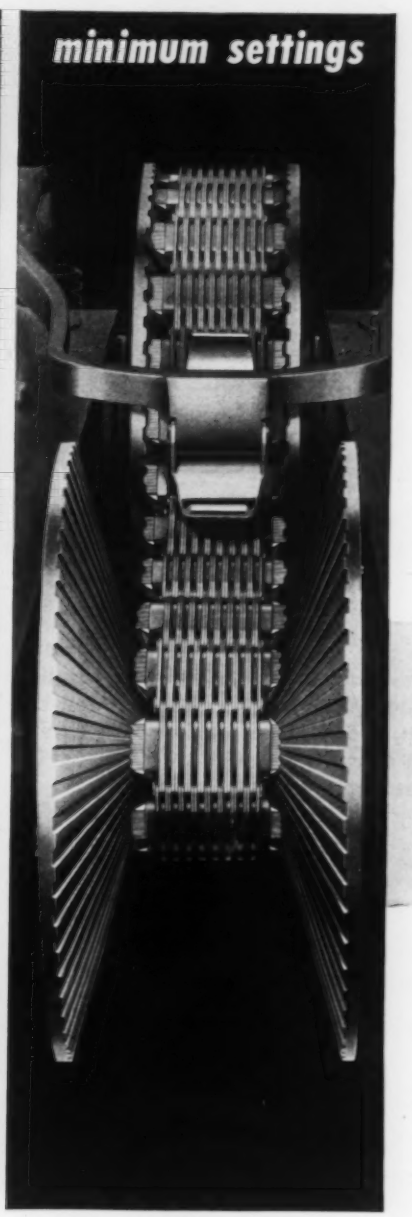
• • •

Nonprofit stamp machine dispenses two two-cent stamps and a penny when a nickel is deposited, three three's and a penny for a dime, or eight three's and a penny for a quarter. If the machine runs out of stamps or change it displays a red light and automatically returns money deposited. Other models offer a wider variety of stamps; another type requires exact change. Installed experimentally now, the machines offer the advantages of stamp service in around-the-clock post office lobbies and reduction of crowds at stamp windows.

For positive, accurate speed control

...there's nothing like P.I.V.

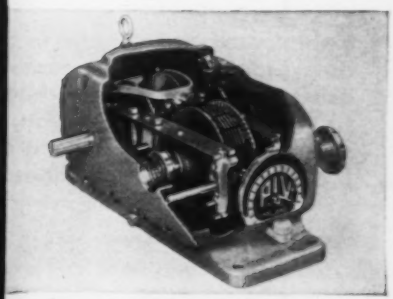




VARIABLE from top speed to minimum speed with no steps, no stops in between. That's Link-Belt P.I.V.—the *only* chain-driven variable speed drive. Teeth—not tension—permit instant ratio changes with no loss of speed, regardless of load conditions.

Slippage? Not a chance—P.I.V.'s chain-to-wheel grip is positive as a gear. In fact, this is industry's most accurate, most reliable mechanical variable speed drive.

Your nearby Link-Belt office will assist you in applying P.I.V. to meet your variable speed requirements. Call today or write for P.I.V. Book 2274 containing complete information on drives from ½ to 25 hp.



HOW P.I.V. WORKS. Exclusive self-tooth-forming chain of P.I.V. consists of packs of free-sliding steel slats which serve as teeth. Chain grips beveled grooves on pairs of conical wheels located on input and output shafts. Speeds are changed by varying the effective diameters of the wheels, as shown at left.

P.I.V. LINK-BELT VARIABLE SPEED DRIVE

LINK-BELT COMPANY: Executive Offices, Prudential Plaza, Chicago 1. To Serve Industry There Are Link-Belt Plants, Sales Offices, Stock Carrying Factory Branch Stores and Distributors in All Principal Cities. Export Office: New York 7; Canada, Scarboro (Toronto 13); Australia, Marrickville, N.S.W.; South Africa, Springs. Representatives Throughout the World. 14.513-A

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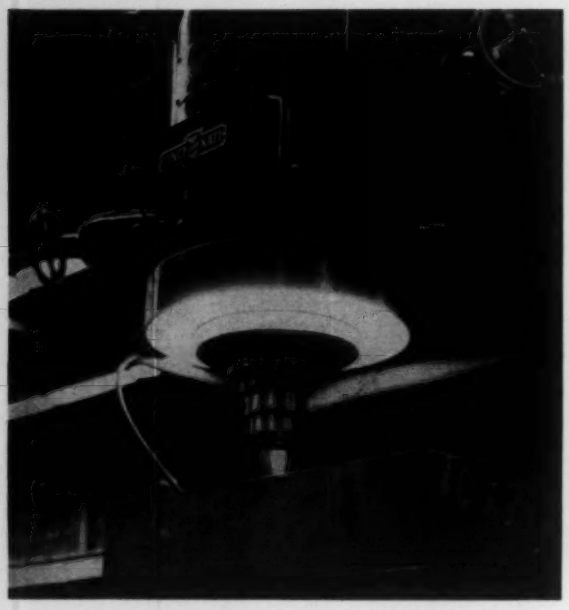


Space-saving thinness of electroluminescence permits application of light in machinery where it is needed most—directly on the work.

Luminous ceilings and walls are conceivable, with the light source applied like wallpaper.

Electroluminescence: A Progress Report

Light source and reflector in one thin sheet—this is a remarkable property of electroluminescence. Room lighting applied like wall paper, and machines with built-in illumination are future possibilities. Some applications are almost ready now. This summary, based on a report from General Electric Co. Inc., describes electroluminescence, present and future.

ELECTROLUMINESCENCE is the most recently discovered means of converting electricity into light. Present forms use crystalline phosphor powders sandwiched between two electrically conducting surfaces, at least one of which is translucent. Alternating-current power connected to the conducting surfaces causes the phosphor to emit light. The device is electrically similar to a capacitor, and has been called a "luminous condenser."

The most unusual characteristic of electroluminescence: It converts electricity directly to light. There are no intermediate stages such as filament heating or conversion of electrical energy to ultraviolet radiation as in fluorescent lamps.

Electroluminescent panels will soon be available for low-brightness applications such as automobile dashboards and aircraft instrument panels. For use in general lighting, however, improvements in brightness, efficiency, and maintenance of light output are necessary.

Why the interest in electroluminescence?

- In theory, it may produce light much more efficiently than any present light sources. Incandescent lamp efficiency is, at best, only 10 per cent; fluorescent lamps, 25 per cent. Electroluminescence may do considerably better.
- Electroluminescence usually comes in thin, space-saving panels. These can be patterned in color, form, and texture. Luminous walls and ceilings are definitely conceivable, with the panels applied like wallpaper. Thinner sheet is ideal for dials or control panels.

Three basic electroluminescent "lamps" appear to have possibilities: glass-faced, ceramic-on-metal, and flexible plastic.

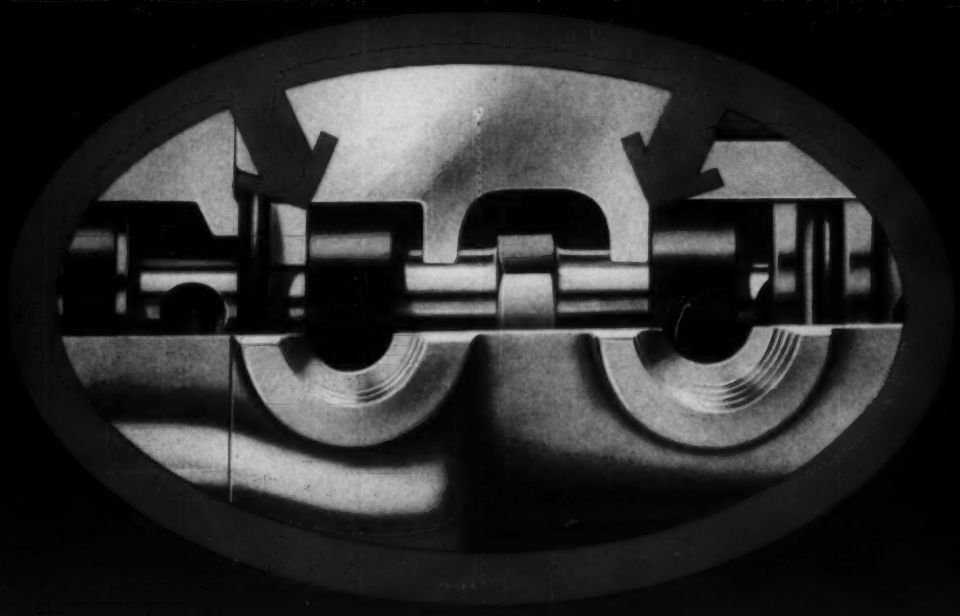
Structural and Sizes: Since the elements of an electroluminescent lamp are very thin, the two conductive layers may be separated by only a few thousandths of an inch. Additional thickness is required for external insulation material and for a backing panel, where needed, to supply structural strength.

Ultimately, there seems to be no inherent limit to the possible sizes and contours of panels. Panels 2 ft square appear practical at present.

Color: Mixtures of phosphors can create a variety of colors, including white. As with any light source, color filters can be applied over the panels, but these reduce light output. Color can also be modified by superimposing translucent fluorescent material over the panel, which emits energy at a different wavelength. For instance, blue-green phosphors can activate a red-fluorescing covering material, with a resultant red output.

Brightness and Light Output: At present, experimental panels operated on regular 120-v, 60-cycle circuits give 3 or 4 lumens per sq ft (foot-lamberts) in green. This is the brightest color, mainly because the

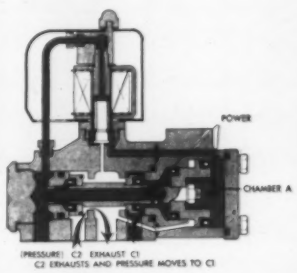
ABSOLUTELY TIGHT SEATING!



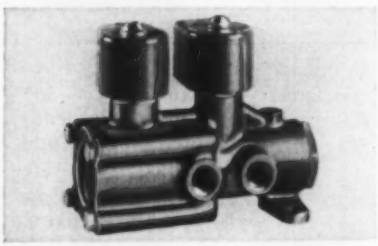
WITH ASCO POPPET TYPE 4-WAY SOLENOID VALVES

Dead tight shut-off—even on air—is assured in these four-way valves through poppet seals, and by a unique combination of metal to metal and resilient seating. No lapping, grinding or close adjustments are necessary — no binding or leaking can occur. Short piston disc assembly travel, basic design simplicity eliminate maintenance problems.

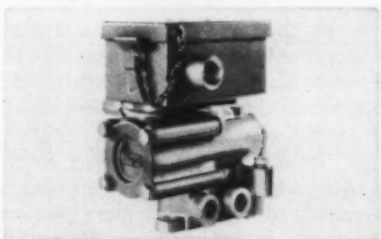
ASCO 4-way Valves are available in $\frac{3}{8}''$ through 1″ sizes, in standard, explosion-proof or water tight enclosures. They can be mounted in any position, and permit cycling rates to 850 per minute.



Operation: ASCO Single Solenoid 4-way Valves are power-driven in both directions by line pressure. When the solenoid is de-energized, line pressure applied to the top of the piston core forces it off the seat, eliminating possible sticking due to residual magnetism. Line pressure is applied to Chamber A, moving the piston-disc assembly to the left. When the solenoid is energized, Chamber A is exhausted and line pressure drives the piston to the right. Single solenoid type (illustrated) operates when solenoid is energized; returns automatically when de-energized.



Dual Solenoid (Bulletin 8344): operates when either solenoid is energized; will not return until opposite solenoid is energized (single solenoid types return when de-energized). In dual solenoid valves, solenoids may be energized continuously or momentarily.



J.I.C. Construction (Bulletin 8346) ASCO Single and Dual Solenoid Valves can be furnished to Joint Industry Conference requirements—valves are provided with subplates, vapor-proof solenoid enclosures, and manual overrides, and are electrically inoperative with the cover removed.

New! Catalog No. 202 covers the ASCO line of Solenoid Valves. Write for your copy today.

For Immediate Delivery . . . World's largest stock of Solenoid Valves. A complete Solenoid Valve Stock List will be sent to you with your copy of Catalog No. 202.

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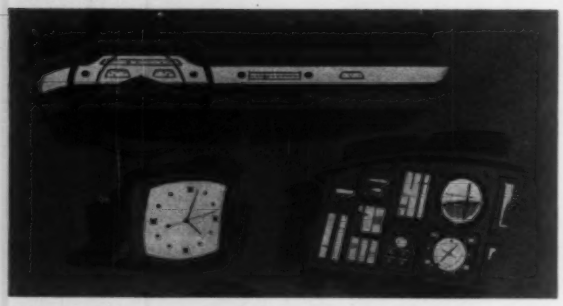
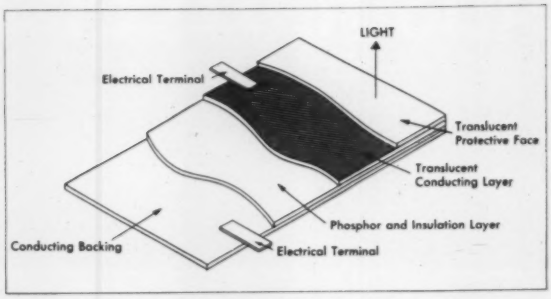


Electroluminescent panels and cells will soon be available for low-brightness applications such as these.



Essential elements of an electroluminescent lamp.

eye is sensitive to it. Brightness of white is about one-half that of green.

A benchmark: It would take 400 sq ft of white electroluminescent panels to produce the same amount of light as a 60-w incandescent bulb, both operated at 120 v, 60 cycles; or 1300 sq ft to match a 40-w white fluorescent lamp.

Operating the panels at higher voltage and frequency produces greater brightness and light output, but generally lower efficiency and shorter useful life. Light output appears to be little affected by usual indoor and outdoor temperatures.

Life and Maintenance: Useful life is indeterminate, but seems to be of the order of thousands of hours. Failure is gradual, rather than sudden. Light output and efficiency fall off more rapidly at higher voltages and frequencies.

Lumen maintenance is much poorer at higher humidity, but sealing the panels within a transparent moisture-tight enclosure can eliminate this problem.

Electrical Characteristics: Panels may be designed for various voltages. Since the electroluminescent panel is, electrically, a capacitor, the current throughout it leads the voltage, with a leading power factor of about 30 per cent. Electroluminescent panels thus might be useful in improving the system power factor when used with lagging-current loads such as fluorescent lamps on low-power-factor ballasts.

Power Supply: In addition to standard 120-v, 60-cycle power, special power supplies providing nonstandard voltages and frequencies may be used. Where direct current is the primary power, as in automobiles and boats, special conversion equipment would be needed. In many modern aircraft, 120-v 400-cycle power is available, so electroluminescence could be used for instrument panels and other lighting.

Even where standard ac power is available, it ultimately may be more economical to convert it to higher voltage and frequency for some applications.

Future Possibilities: Electroluminescence combines the light source and the reflector or diffuser in one thin sheet, so that depth or volume required to create an area of brightness is at a minimum. Simplicity and light weight are additional advantages. The new light source lends itself to standardized modular construction as well as to manufacture in contours to fit specific application.

Pictures Young Engineers Unhappy in Industry

Says Unkept Promises, Stockpiling, Spur Turnover

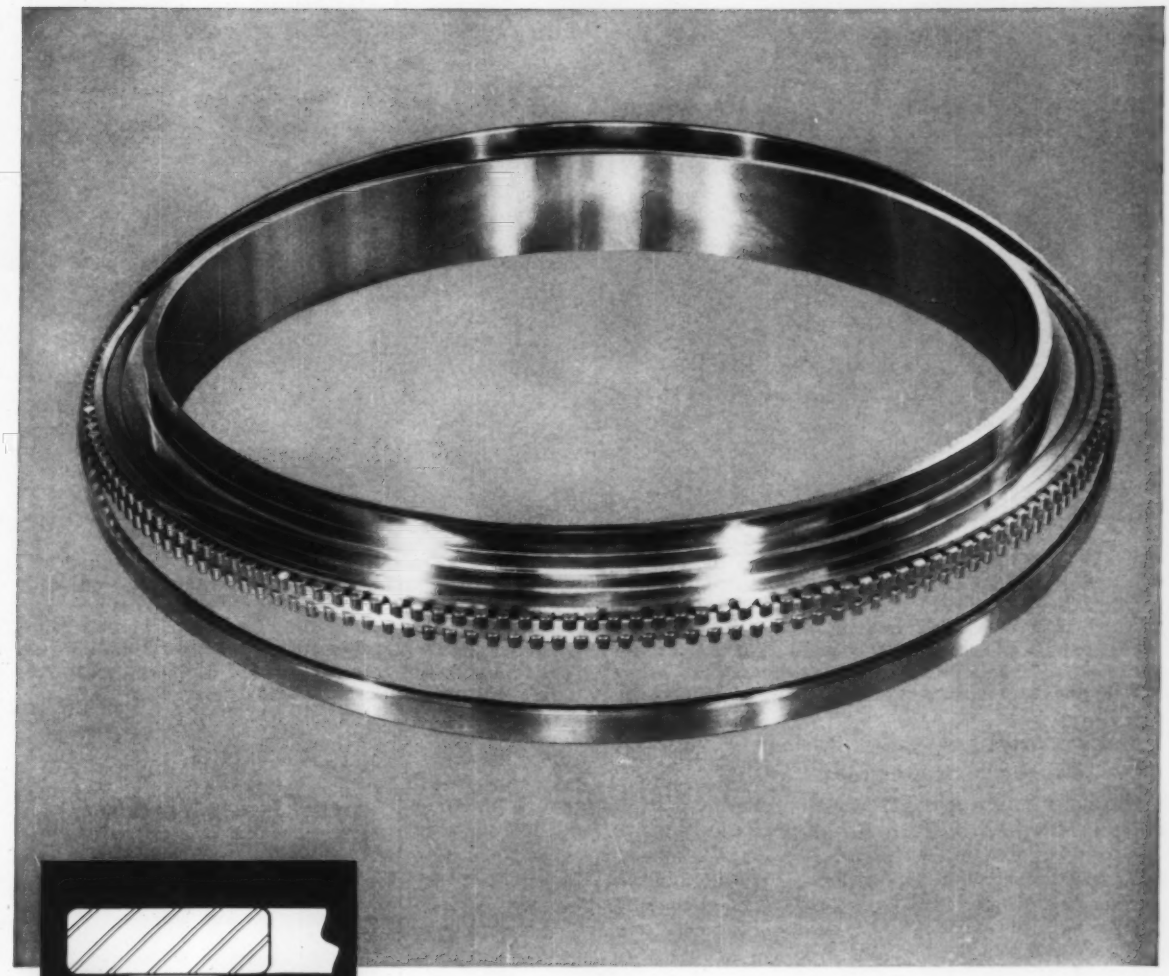
DETROIT—Many engineering graduates recruited a few years ago are now trooping back to their college placement offices to seek new jobs. The principal reasons—companies are not keeping their promises and often don't even have work for the men.

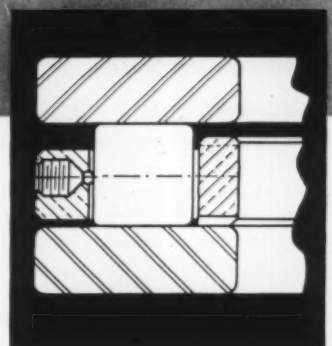
According to J. D. Staley of the American Management Association, in a paper delivered at the recent ASME semiannual meeting, one-fifth of 1300 engineers surveyed recently said their first job did not fit the recruiter's description. One said he had spent his time removing, checking, graphing, and filing charts. Others pointed out that the experienced, senior scientists, with whom they were supposed to be working, were seldom in sight.

It also seemed an effort to adjust from the lavish entertainment designed to provide the "personal touch" in company recruiting to the on-the-job "impersonal touch" that predominates. Many engineers report feeling no sense of identification with their company or its product. These were among reasons cited why companies suffer three to five per cent yearly turnover in career engineering personnel.

Like most people, Staley pointed out, engineers want recognition, security and "belongingness," and it is not just the new employee who is dissatisfied in this respect. Engineers want to be classed as part of the management team, but in most companies, they are grouped with the nonprofessionals. Frequently, they are denied sufficient opportunities to become active or to take office in engineering societies and are often assigned to jobs that do not require a high degree of engineering ability.

Even though starting salaries are high, increases are not. One engineer noted that after five years with his company, he makes $130 a week. His company now hires graduates at $125 and he complained that the plant machinists make more than he does for the same hours.





Running mate of the Torrington Radial Roller Bearing pictured is this Torrington Cylindrical Roller Thrust Bearing 52 in. OD, assembled face runout 0.0004 in., capacity 222,000 pounds at 100 rpm.

A picture of precision... 57.500 inches in diameter!

Here is an ultra-precision Torrington Radial Roller Bearing, custom-built for Wickes Machine Tool Division's 48" Center Drive Profile Lathe.

Almost five feet (57.500 in.) in diameter, it has a total inner race runout of only 0.0005 in. Its 344 rollers are held uniform in diameter within 0.00005 in. Radial capacity is 318,000 lb. at 100 rpm. Rollers are staggered in a one-piece, fully machined bronze cage for precise guidance and cool running. The bearing bore is tapered one inch per foot, and carefully mated to the spindle which was also ground by Torrington.

Such precision is possible only through specialized equipment and highly practiced skills—the same that lie behind the quality of every Torrington bearing, standard or special. Not every bearing order calls for such precision—but each is given the extra measure of care that makes Torrington quality a byword in industry. **The Torrington Company, South Bend 21, Ind.—and Torrington, Conn.**

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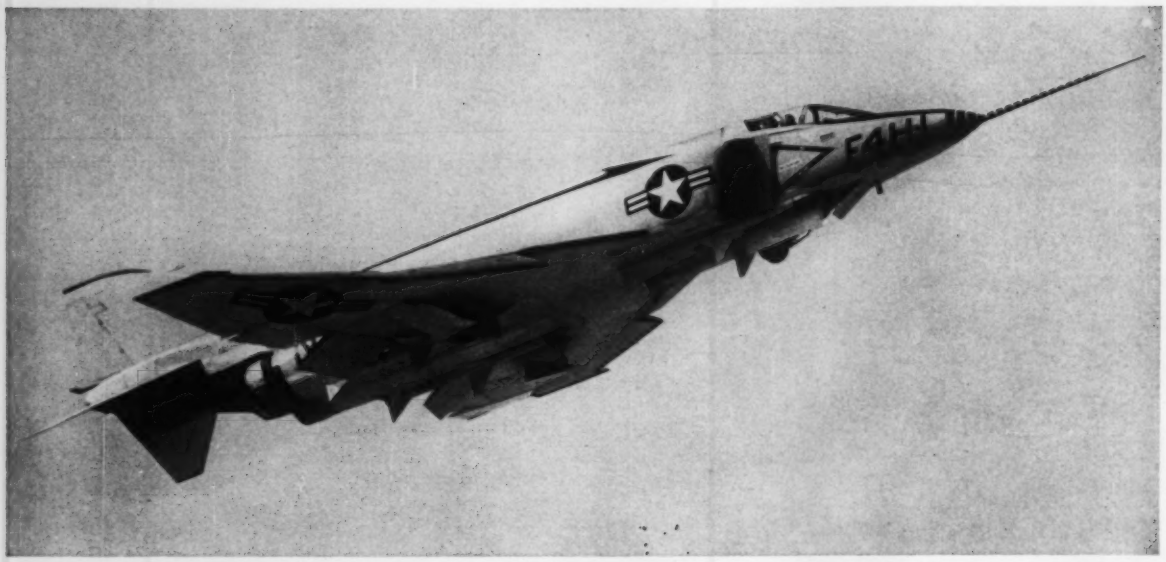

ALL-AROUND PERFORMANCE describes the Navy's new twin-jet, two-place F4H-1 fighter plane. Designed by McDonnell Aircraft, the new weapons system is powered by two General Electric J-79 engines and is claimed to be the fastest Navy fighter in the air. It carries a radar-missile system for all-weather interception and can make long-range delivery of nuclear bombs. If accepted in volume, the F4H will join an impressive array of front-line Navy aircraft — North American's A3J attack bomber, Douglas, F4D Skyray, which just established climbing records, and Chance Vought's Crusader, one of the world's fastest fighters. All will operate from the Navy's four new controversial 75,000-ton Forrestal class aircraft carriers.

Mr. Staley urged appraisal of engineer programs, particularly in the areas of salary, recruitment, job content, orientation, and supervision. He said that where attempts at reforms were made—in upgrading engineers, providing more information relating to their work, encouraging them to take courses, and adjusting salaries of older employees to reflect changes in beginners' salaries —turnover rate shrank amazingly.

Automated Rubber Molding Makes Precision Parts

STRATFORD, CONN.—An automated process for high-volume custom molding of rubber parts (synthetic or natural) is said to provide exceptional uniformity and precision at low cost.

Developed by Ohio Rubber Co., the new equipment requires one operator to keep the machine supplied with compounded stock, and to remove containers of finished parts. Production rates as high as 200,000 pieces per day are possible from single-cavity self-registering molds. This process was previously too slow to be economically feasible in many cases.

Because of the continuous nature of the operation, time and temperature are precisely controlled throughout the molding-curing cycle. The single-cavity molds provide accurate application of pressure resulting in uniform flash and high precision. Diameters, for example, can be accurate within $\pm$ 0.003 to 0.005 in., depending on size.

According to Ohio Rubber, the process is best suited to relatively small parts, required in large quantities, which are functional and therefore require a significant degree of dimensional accuracy. Parts already in production include seals for automotive shock absorbers and universal joints, washers for water conditioner quick-connectors, end caps for electric condensers, aerosol container valve parts, engine valve-stem deflectors, and fastener components.

Inertial System Will Guide X-15 in 3600-mph Flight

Avoid Both Bounce and Burn During Return Trip

WASHINGTON—The rocket powered X-15 research aircraft, scheduled to fly 3600 mph at altitudes of 100 miles, will require a better than human pilot during much of its flight. During the critical re-entry phase, for example, the plane will burn up if re-entry is too steep, or will "bounce" to an uncomfortably high altitude if trajectory is too shallow.

Accordingly, decisions during this phase of the flight will be made by an advanced inertial guidance system announced recently by the Air Force.

Developed by Sperry Gyroscope Co., the new system is composed of a three-gyro stable platform which provides critical attitude, velocity, distance and altitude sensing; and a lightweight computer to interpret the data. Components will withstand 10-g accelerations, and the system itself is impervious to jamming.

Electronic Plotters Graph, Map Computer Output Data

LOS ANGELES—Automatic graphing devices now translate computer output data directly into finished drawings or maps. Developed by the Benson-Lehner Corp., Los Angeles, the Electroplotter H and its map-making companion, Electroplotter S (shown), can eliminate much of the meticulous pencil-pushing done today by technical personnel.

One application of the Electroplotter H is in the national highway program already underway. Measurements of the terrain are currently fed into large automatic

computers, which calculate where and how much earth should be removed and where it should be placed. These earth-moving instructions must be given to the highway builder in the form of cross-section graphs. Previously prepared by hand, such graphs can now be drawn automatically in a fraction of the time it would take a team of trained engineering draftsmen.

For map making, the new Electroplotter S can do the day's work of a topographical draftsman in 15 minutes. One human bottleneck that will be eliminated is the delay now experienced in the preparation of substrata geophysical maps for locating underground oil deposits. The Electroplotter S draws these maps automatically, working directly with the output of the computer.

Correction: The electronic line tracer reported on Page 38 of the May 29 issue was incorrectly described as having been developed *by* the NCG Div. of National Cylinder Gas Co. It should have been noted as having been developed *for* NCG by Canadian Westinghouse Co. Ltd.

DRAFTING TRENDS

At the Caterpillar Tractor Co., Joseph Bryant (right) of the Tool Design Department inspects PTM with Marvin Merritt, Frederick Post dealer in Peoria, Illinois.

Improved tracing medium has film-like transparency

Some products remain "news" for several years; usually because their qualities are revolutionary. PTM (Post Tracing Medium) is an excellent example. The transparency, stability and uniform drawing surface far exceed accustomed standards.

The secret of the transparency lies in a patented "welding" process. Special 100% rag paper stock is first impregnated with transparentizing materials. The sheet is then processed under tremendous pressure, literally fusing the materials together into a continuous mass. This produces a sheet no longer resembling paper, but rather a plastic film filled with clear fibers for added strength—a remarkable tracing medium with almost glass-like transparency.

The stability and smooth surface result from the pressure applied during the process. With air pockets eliminated, there are fewer pores in the paper subject to atmospheric changes. PTM offers dimensional stability ordinarily not found in paper based products. The same pressure eliminates all surface variations and traces of grain. PTM provides a smooth, even sheet with uniform drafting performance in every direction.

Non-clogging fountain pen speeds ink drawing

Here's a fast, easy answer to time-consuming, tedious inking jobs. It's the Rapidograph . . . a non-clogging fountain pen specifically designed to produce constant width lines with India Ink. As simple to use as a pencil, the Rapidograph's continuous supply of ink cuts inking time up to 50% through the elimination of frequent stops for refilling. Use it also for lettering and template work. Five *interchangeable* pen points are available for Rapidographs in varying weights of lines from broad, medium, fine, very fine to ultra fine.

Further information on these items is available from the Reader Service Division of the Frederick Post Company, 3652 N. Avondale Avenue, Chicago 18.

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Friendly inferno— to make BETTER GEARS

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BETTER GEARS that offer the advantages of lower installed cost, economical and dependable service on the job for which you buy them . . . gears that do credit to your product and your reputation.

Our gear engineers are available for consultation. Just write.

In this controlled atmosphere furnace, 100% forced convection heating of gears by Automotive Gear Division insures uniform heating of every part to the desired temperature. Through the entire operation—pre-heating, carburizing, hardening and modified Marquenching or regular quenching in selected grades of oil—time, temperature and atmosphere in each zone are automatically controlled. Thus, the quality that is cut into the gear is retained.

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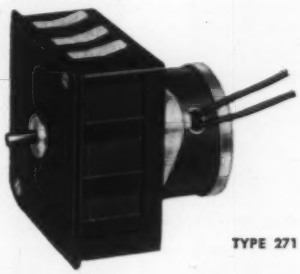
for cost-conscious manufacturers . . .

4 new solutions to timing problems

Over the years, Cramer engineering and manufacturing skill has built an unequalled reputation for quality in timers and timing motors. Today, the same skill . . . plus cost-cutting innovations in production methods . . . brings you four new units with the same outstanding quality at substantial price savings. Ask for prices, get the detailed specifications, and you'll see that Cramer quality means economy *now* — not just in the long run.

Cramer Controls Corporation
Box 6, Centerbrook, Connecticut

New Interval timer



TYPE 271

Cramer Type 271 is a compact, manually-set timer for "on" and "off" control of a wide variety of equipment . . . such as driers, ovens, photographic apparatus, battery charges, and various types of production machinery. Turning the dial pointer clockwise to the desired setting transfers the load switch, starts the motor and initiates timing. The pointer then indicates timing progress as it moves back toward zero. At the end of the set time, the load switch transfers to its first condition, and the motor stops.

TIME RANGES: 11 standard ranges, from 45 seconds to 24 hours.

LOAD SWITCHES: 1 or 2, as required; SPDT open blade.

CONTACT RATING: 30 amps resistive load, or ⅓ hp. motor load, at 115v A.C.

TIMING ACCURACY: within ½ of 1% of full scale time.

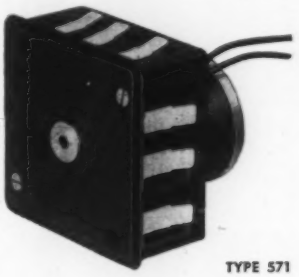
CONSTRUCTION: rugged, industrial design, using heavy-duty components.

POWER REQUIREMENTS: standard A.C. (50 and 60 cycle) and D.C. voltages.

MOUNTING: 2-hole face mounted, or single center hole.

WRITE FOR BULLETIN PB-271

New Cycling timer



TYPE 571

Cramer Type 571 provides reliable and inexpensive repetitive switching, or programming, in a wide variety of built-in applications . . . such as vending machines, displays, domestic appliances, production or process equipment, and many others. The timer starts when power is applied, stops if power is interrupted, and resumes cycling at the same point when power is restored. It can be wired for single cycle and stop operation, or for continuous cycling. During each cycle, 1 to 4 load switches are actuated, at times and for durations determined by cams cut to the user's specifications.

SPEEDS: 18 standard speeds, from 1 rpm to ⅛ rpd.

LOAD SWITCHES: 1 to 4 as required; SPST or SPDT, open blade.

CONTACT RATING: 30 amps resistive load, or ⅓ hp. motor load, at 115v A.C.

CAMS: precision-cut to user's programming requirements, locked to a square shaft that eliminates slippage.

TIMING ACCURACY: within 1½% of full cycle at each operating point.

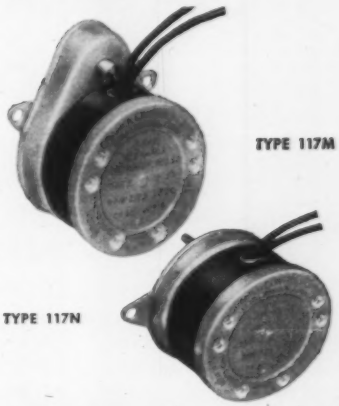
CONSTRUCTION: rugged, industrial design, using heavy-duty components.

POWER REQUIREMENTS: standard A.C. (50 and 60 cycle) and D.C. voltages.

MOUNTING: 2-hole face mounted, or single center hole.

WRITE FOR BULLETIN PB-571

2 new timing motors



TYPE 117M

TYPE 117N

Cramer Type 117M and Type 117N are unequalled examples of performance-plus-economy in permanent-magnet synchronous timing motors. Delivering a full 30 in. oz. torque at 1 rpm, these powerful, accurate, reliable motors incorporate all of the engineering advances that have made Cramer the first choice of designers who put quality first. And their low cost is fast making them the first choice of large volume manufacturers who must put economy first. With standard gear train (Type 117M) or space-saving round gear train (Type 117N), a great range of standard speeds, and enough torque to handle the heaviest loads without extra linkages, they are ideal for appliances, vending machines, animated displays, timers, recorders, instrument drives, and many other applications.

SPEEDS: Type 117M—60 rpm to ½ rpd; Type 117N—60 rpm to 1/12 rpm. Special speeds available on order.

TORQUE: 30 in. oz. at 1 rpm.

GEAR TRAIN: fully enclosed, precision hobbed throughout.

OUTPUT SHAFT: stainless steel, selected to order from many standard or special forms available.

ROTOR: permanent magnet, with bronze oilite bearings and permanent lubrication; low rotor speed permits wide range of output speeds.

ROTATION: right, left, or dual (oscillating); patented "No-Back" mechanism; synchronous speed reached within 2 powerline cycles.

FRICTION: 1-way in rotation direction, or 2-way.

TEMPERATURE RISE: 35°C.

AMBIENT TEMPERATURE: −4°F to +131°F.

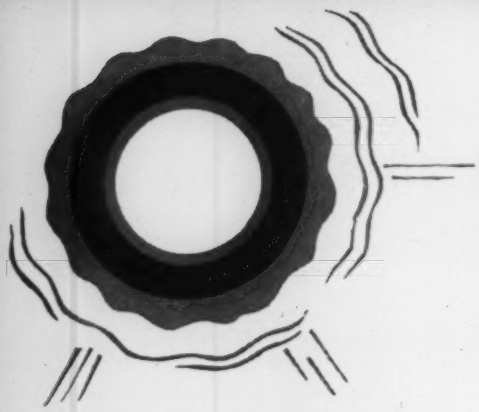
RATINGS: 115v and 220v, 60 and 50 cycles.

WRITE FOR BULLETIN PB-117

WHEN TIME IS YOUR PROBLEM, CALL CRAMER

CRAMER CONTROLS
CORPORATION

Circle 412 on Page 19



SOLAR ENERGY

- - - *Possibilities unlimited*

The sun supplies energy thousands of times faster than man can use it, lending itself to man-made contrivances for heat generation or refrigeration, voltage production, photochemistry, housing . . .

THE SUN RAINS energy on the earth at a rate equivalent to burning 20 billion tons of coal in one hour. It supplies thousands of times more energy than man can use. It hurls photons, tiny "bullets" or packets of energy, against earth, rocks, and foliage. Some photons are reflected back, skyward, out of man's reach. Most are captured in solar-photon processes, by which their energy is eventually converted to heat, growth, phosphorescence, or chemical changes.

Nature uses solar energy on a prodigious scale. Heat from the sun evaporates the sea water which falls again as rain or snow, and it sets in motion the air masses which constitute our winds. The constantly recurring miracle of photosynthesis created, in ancient eras, the plants which today are our fossil fuels.

In a broad sense, all of the energy used today, with the possible exception of atomic energy, comes from the sun. For the future, man can look toward solar radiation as an inexhaustible energy source which he can use directly for his own ends—after he finds economical ways to use it.

Heat or cold from the sun

One application of solar energy—heat generation—is practical today in every sense of the word. But heat generation makes possible also refrigeration processes, already in use in many conventional applications. Hence, by the use of proper equipment, temperatures can be produced which range from subzero to more than 5000 F through the use of solar radiation.

The sunlight reaching the earth is relatively diffuse; its energy does not exceed about 300 Btu per sq ft per hour. As a result, solar radiation must be concentrated to produce temperatures great enough to generate high-pressure steam or to permit cooking. Simple flat mirrors can be used to reflect sunlight from a large area to a relatively small target, or to heat a cavity such as an oven. Successful ovens of this type have been designed by Dr. Maria Telkes of New York University. They are of major importance in those parts of the world where fuel is scarce and very expensive.

Where really high temperatures are needed, a parabolic mirror is used. Here a movable flat mirror reflects the rays of the sun to a fixed concentrator, which reflects the rays to its focal point, where a miniature image of the sun is formed. If the mirrors are accurate and highly polished, temperatures as high as 5000 F can be produced at the focal point. Such furnaces are used in many industrial and governmental laboratories for studying the properties of materials and reactions that proceed at very high temperatures.

The largest such furnace in the world today is located at the French Solar Energy Laboratory in Mont Louis, and still larger ones are planned by both the French C.N.R.S. and the U. S. Air Force. These will be used primarily for research at very high temperatures. The French furnace will also be used to process materials that cannot be handled in conventional furnaces.

Refrigeration can be produced by at least three processes. The conventional mechanical refrigerator, such as is used in millions of homes, could be operated by sun-powered engines but, for now, this does not appear encouraging. The absorption refrigerator, familiar in the form of gas fired refrigerators or steam-operated air conditioners, can also be activated by solar heat. This has already been successfully demonstrated in the Russian Solar Laboratory at Tashkent and the French Research Center at Mont Louis in the Pyrenees. Intermittent refrigeration has been accomplished at the University of Wisconsin, and some success has been achieved in continuous refrigeration at the University of Florida.

All of these devices operate on the same general principle. A concave parabolic trough concentrates the sun's rays upon a device which generates steam or heats a refrigerant absorber. The steam drives ammonia or Freon out of solution,

JOHN I. YELLOTT
Executive Vice President
Association for Applied Solar Energy
Phoenix, Ariz.

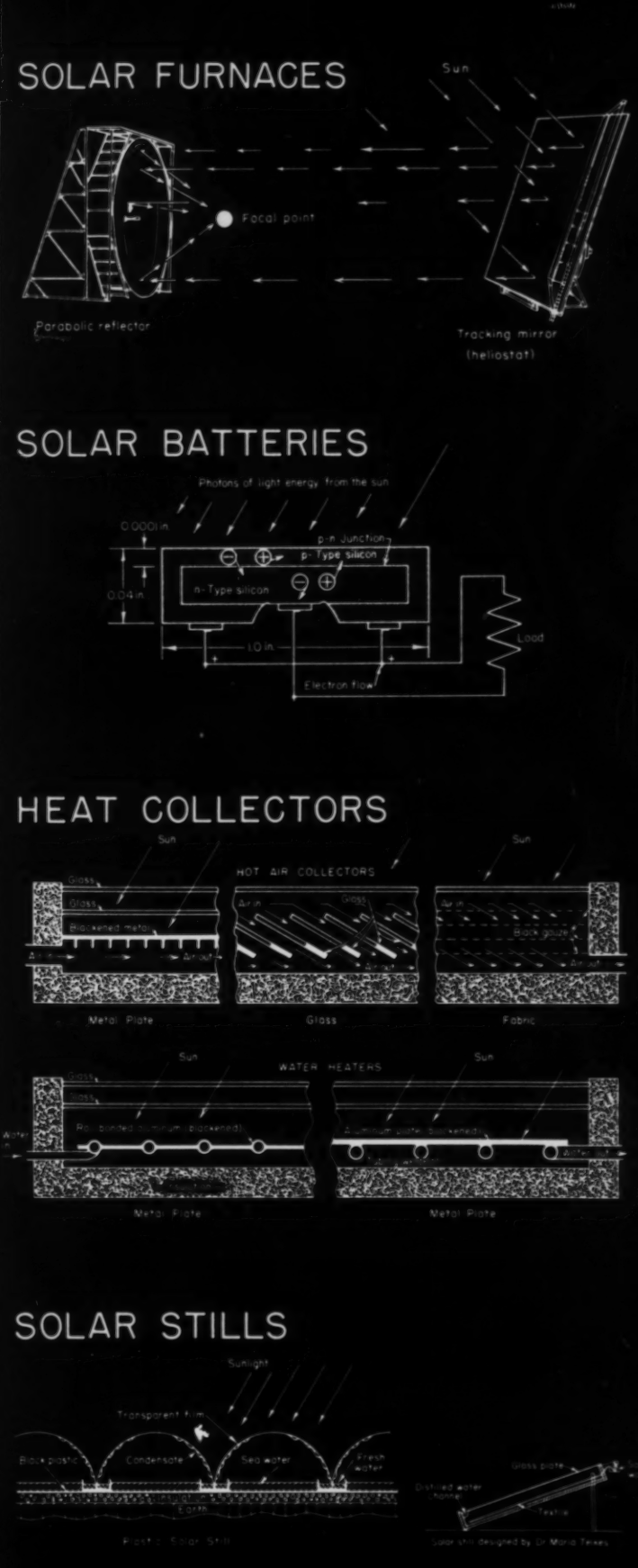
after which it is condensed, and then expanded through refrigerating coils. The process is used on a large scale in many applications where waste steam is available. It offers considerable promise for use with solar heat collectors, which are suitable also for providing winter space heating.

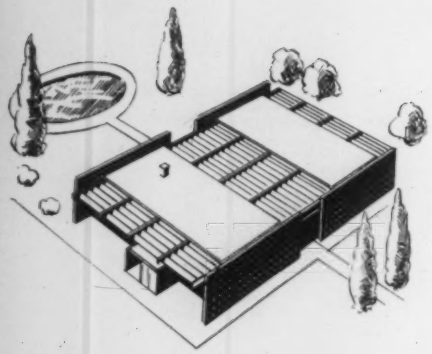
A type of solar refrigeration which has been pioneered in Russia uses a jet ejector to evaporate refrigerant from a container, thereby lowering its temperature. The vapor which operates the jet is obtained from a solar heat collector. The system has not yet been tested in the U. S., but a research program is now being planned to try it out at the University of New Mexico.

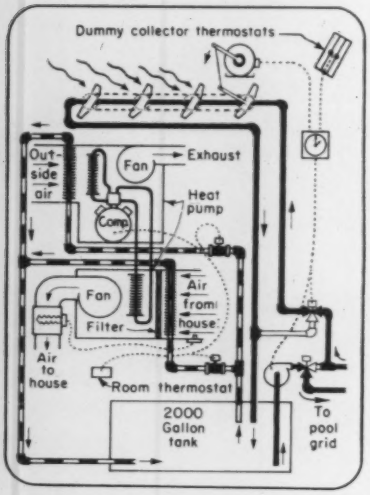
Refrigeration by solar energy is potentially of the greatest importance, because many of the more densely populated sections of the world lie in tropical regions where there is plenty of solar energy and a great need for refrigeration. But there is no electricity or fuel to produce that refrigeration by means of conventional equipment.

Voltage from solar energy

More than 100 years ago, a French chemist discovered that light falling upon an electrolytic cell could cause a current to flow. Within another few years, other chemists and physicists found that solid substances could also be made to generate electricity when they were properly illuminated. A whole industry has since grown up about photoelectric devices using the element selenium.







Solar house in Phoenix will be sun-heated throughout the entire year. Striking design was cooperative project of Solar Association and Phoenix Association of Home Builders.

The maximum efficiency of selenium devices, though low, was high enough to allow them to be used as photographic exposure materials, control devices, and other special products. Indeed, a few lights were lit, motors run, and radios operated by selenium solar cells, but the outlook for substantial power generation from the sun was dark.

Three years ago, a team of scientists at the Bell Laboratories, seeking to produce improved transistors, found that highly purified silicon, suitably treated, was an excellent material for producing electricity from solar energy. The silicon cell constitutes a major development because, in one step, the efficiency of converting light into electricity was raised by a factor of ten.

Today the silicon solar cell is at work in many applications. Because each cell must still be made from a thin slice of single crystal, its output is limited. Still, a battery of 100 cells can produce enough energy to power remote radio transmitters, telephone lines, or neon lights on a mountaintop beacon. One very important application is supplying electrical power to radio transmitters, in satellites.

Since the silicon cell has no moving parts to wear out, there is every reason to believe the cell will continue to operate indefinitely. This means that a satellite or space vehicle can, within the limitations of the area exposed to the sun, continue to transmit information just as long as the other components of its radio system remain intact.

Development of the silicon solar cell ranks as a triumph for basic research, and there is good reason to believe that other research groups will succeed in developing a large-area, photoelectric device which can produce much greater quantities of electricity at lower costs. At the present time, the economics of the situation do not permit solar electricity to compete with power generated in central stations, or even from small fuel-burning engines. The time will come, however, when photoelectric devices will be sufficiently low in cost to permit isolated houses to obtain useful quantities of electricity from the sunlight falling on their roofs.

Photochemistry

Another familiar use of solar radiation is to make chemical changes. The most familiar of these is in the field of photography, where light causes changes in sensitized films. Once used only to distinguish between light and dark, the photographic process has now been refined to the point where it can detect, record, and reproduce all colors of the rainbow.

Processes have been discovered by which light can, to a very limited extent, decompose water into hydrogen and oxygen. This gives rise to the hope that fuels of the future might conceivably come from sea water. This, however, is far in the future, because the yields of present processes are much too small to make them commercially interesting. However, at MIT and the Stanford Research Institute, work is underway on the photolytic decomposition of water, and positive results have been obtained already. If hydrogen and oxygen can be produced in sufficient quantities, man can, with the aid of inexhaustible carbon supplies in the world's limestone deposits, eventually produce all of the hydrocarbons needed. Or, the gases can be stored and later burned to produce heat.

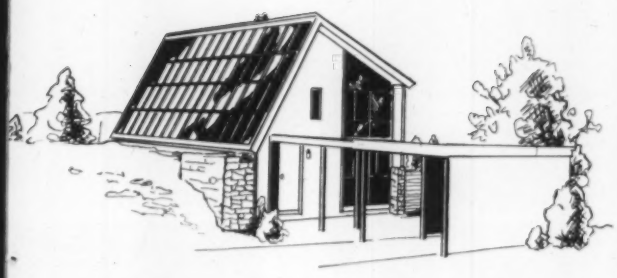
Solar stills

Solar stills for producing fresh water from salt have been used in various parts of the world for almost 100 years. Only recently, however, has man learned to capture and condense the evaporated water, to give him potable supplies in regions where there is only salt or brackish water. In World War II, survival kits were furnished to virtually every naval aviator. With one of these small stills, he could produce enough water each day to keep himself alive, using only salt water and sunshine.

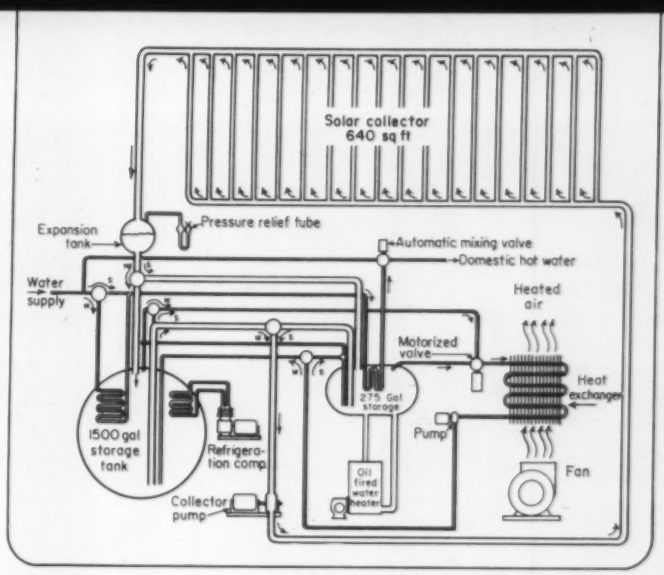
The principle of solar stills is simple. Sunlight passing through a transparent cover heats a thin layer of water, held in a blackened container. Some of the water evaporates, and the vapor condenses on the underside of the transparent cover. The cover traps the heat of the sun by permitting sunlight to pass into the still, but preventing the enclosed heat from escaping. Glass has been the conventional material for covering solar stills, but, within the past two years, industrial laboratories have developed several transparent plastic films, which do an excellent job.

Du Pont's laboratories have produced several weatherable plastic materials which have optical properties similar to those of glass, but which are so strong that they can be used in thicknesses no greater than 0.003-0.005 in. These are so light they can be supported by air alone and do not need elaborate structures. Experimental stills using such films have given encouraging results, and it is reasonable to expect they can be built at costs low enough to produce drinking water.

Because irrigation water must be still cheaper by a factor of almost 10 to 1, its distillation by means of solar energy is still impractical. But solar-distilled drinking water is well within the realm of possibility. Its cost is considerably below the rate being paid in particular localities such as Key West, Fla., where fresh water must be imported through an 80-mile pipeline.



Suburban home is MIT Solar House IV. Previous designs proved efficiency of collectors—included a student home on campus.



Housing, courtesy of the southwestern sun

Of all solar-operated devices, the sun-heated house is perhaps the most intriguing. The solar house at Phoenix, Ariz., resulted from an architectural competition, sponsored by the Association for Applied Solar Energy, which was to provide: 1. Architectural distinction. 2. An energy collection area sufficient to meet all heat requirements of the house and swimming pool during a normal Phoenix year. 3. Sunshine control to minimize the summer cooling load.

The Solar House, completed last April, is heated by an array of 68 louvers, mounted in 17 parallel rows between the bare steel roof beams. Pipes inside the louvers carry circulating water. After being heated, the water returns to the buried 2000-gal storage tank, which is insulated with 4 in. of Fiberglas.

Fans in two heat pumps circulate air through the two wings of the house. Heat for either wing is supplied by water pumped from the storage tank through coils mounted on the intakes of the heat pumps.

Cooling can be accomplished at any time of the year by means of heat pumps. Air distribution within the house is accomplished through a floor-duct system. After warming or cooling the floor, the air is discharged into the rooms through grilles. Air is returned to the circulating units through ceiling grilles, concealed downcomers, and underground ducts.

Housing, courtesy of the northeastern sun

Designed to meet modern living requirements, MIT Solar House IV was completed last March in Lexington, Mass. The result of 20 years of research, the house was built to demonstrate that enough facts and equipment are now available to combine a reliably engineered solar heating system with a house designed for comfortable suburban living in a northern climate.

The most striking feature of the house is its solar collector. It consists of 640 sq ft of glass, two layers thick, over a similar area of 0.0025 in. thick aluminum sheet, which is painted black. While the aluminum sheet absorbs the solar energy, the glass lets the sunshine in, but keeps the longer waves of heat energy from passing right back out again.

Energy is trapped by circulating water through copper tubes attached to the aluminum sheet. This hot water is stored in a 1500-gallon basement tank. To heat the house, hot water from the tank is pumped through a heat exchanger, which functions like an automobile radiator to transfer the heat from the water to a stream of air. This air is forced through ducts and registers to heat the living spaces.

The system is designed to use between 30 and 50 per cent of the total energy received by the solar collector, and to provide between 75 and 80 per cent of the house heat from solar energy. It also supplies an abundance of hot water the year round. The house uses a small auxiliary oil furnace for heating whenever there is a succession of sunless days. But the present solar system can take care of up to three cloudy days in a row if they have been preceded by a stretch of reasonably mild and sunny weather.

For summer operation the oil burner water tank is connected to the roof collector to provide hot water and the large 1500-gallon water tank, which is used for winter solar heating, is refrigerated so that the forced-air system may be used to condition the house.

"While the cost of heating this solar house will naturally be very low," says Prof. L. B. Anderson, "the initial cost of the heating equipment will be too high to justify an installation by the average home owner in the near future." He estimates that the heating system for this house costs about six times as much as a conventional heating system giving equal comfort, but believes a study of the operating data of this solar house will lead to further cost reductions.

Its future

Solar energy today is in the same stage that atomic energy went through prior to 1940, except that there are no foreseeable military applications, and hence no multibillion dollar research projects. There is no secrecy or government supervision either, and private capital has done virtually all of the research which has been accomplished up to this time.

Far more development is needed to produce solar devices as cheaply as they must be in order to be widely adopted, but we must remember that, in the final analysis, solar radiation is the earth's only inexhaustible source of energy. We must learn how to use it most effectively.

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Circle 413 on Page 19

Simply operated device startles people with proof of their inability to communicate

Training device shows

Poor Communications Are the Rule

A SEEMINGLY SIMPLE (actually, fiendishly clever) instrument tests people's ability to communicate with each other. The test in person-to-person communication involves two people, one to operate the Communimeter and the other to instruct him. Teams usually approach the problem with a confidence bordering on smugness, but leave with a somewhat shrunken view of their own abilities.

All that is necessary is for the "instructor" to communicate to the "operator" the correct settings for five of the ten dials on the instrument panel, and for the operator to set the dials correctly. If the partners communicate successfully, a green light signals success. If they fail, a red light flashes and a bell clangs.

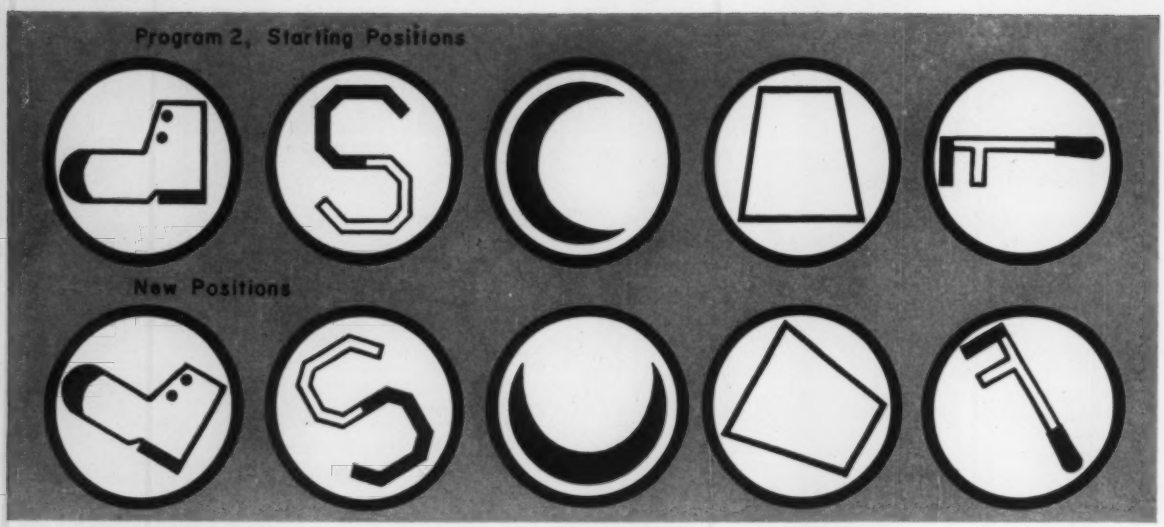
Odds against accidentally turning on the green light without instruction are more than 61 billion to one. Even upon instruction, no operator-instructor team to date has turned on the green light with one-way communication on a first trial. Teams have included a college president and a dean, lawyers, doctors, and business executives. Partners soon learn that mutual understanding can be achieved only with a free, two-way exchange of thought supported by close personal attention and follow-up.

The communimeter was originally developed by L. K. Jonas and W. B. Mansfield of the Engineering Extension Service of the Texas A & M College System. It was intended as a training aid to be used in an industrial communications course, one of a series of short supervisory development courses. The instrument is now being used in the training of executives, supervisors, sales people, police officers, and others to whom accurate communication is a vital problem. Immediate interest in the device, coupled with inquiries from all parts of the country, led to arrangements with the Electronic Devices Development Co. of College Station, Tex., to manufacture the instrument.

The problem of communicating

Because all of us live amid poor communications, we usually fail to realize our shortcomings in this area. This unawareness explains why the Communimeter "shakes up" people taking part in tests. Impact of the demonstration stems too from the fact that it signals communication failures in an unmistakable manner.

Experiments with the device suggest that many people are quite naive about the problems involved in accurate communication. At first, the innocent-appearing instrument and its function impress the team as being almost elementary in nature. They usually launch into the project with a show of complete confidence. Invariably, however,



Typical instruction sheet shows five dials to reset.

they quickly run into trouble. Fairly good communication is not enough to turn on the green light. Successful operation of the Communimeter requires a high degree of precision beyond that generally employed in person-to-person communication. People become visibly frustrated when they are able to see how imperfect their communication techniques are. This is true even when they strive for accuracy.

One-way verbal instructions alone prove hopelessly inadequate where real precision in communication is needed. The demonstration points up conclusively that accurate, effective exchange of thought and feeling can be accomplished only with painstaking effort. Every participant in the Communimeter experiment has become thoroughly convinced that effective communication is far from simple.

How the Communimeter operates

The goal of the team is to operate the device so that the green panel light goes on when the test button is pressed. Five pairs of dials on the front panel each carry a symbol. Each symbol is different from the others, although the symbols on each pair are almost—but not quite—identical.

At the start of the demonstration, each dial must be positioned as shown on the photo. All of the dials are free to be turned continuously in either direction. However, only five of the dials, one of each pair, must be reset. An instruction sheet given to the "instructor" shows him only the five dials to be turned by the "operator." The instructor must verbally identify each of the five dials to be reset, and must also describe the new position for each dial. The position of a *program selector* control permits choosing any one of five dial configurations for the experiment.

After the operator has reset the five dials correctly, depressing the *test* button turns on the green light. If any mistake has been made, however—if the wrong dial has been turned, or if any dial has been set incorrectly, the flashing red light and the clanging bell give prominent evidence that the instructor and operator have failed to communicate effectively.

What the Communimeter shows

The Communimeter strikingly points up facts of communication that are often overlooked:

1. Words mean different things to different people. The listener reacts not to the word itself, but to what it means to him. Past associations also color his interpretation of gestures, symbols, and actions.

2. It is all but impossible for a speaker to convey a picture or concept so that the listener will perceive exactly the same image that the speaker has in mind.

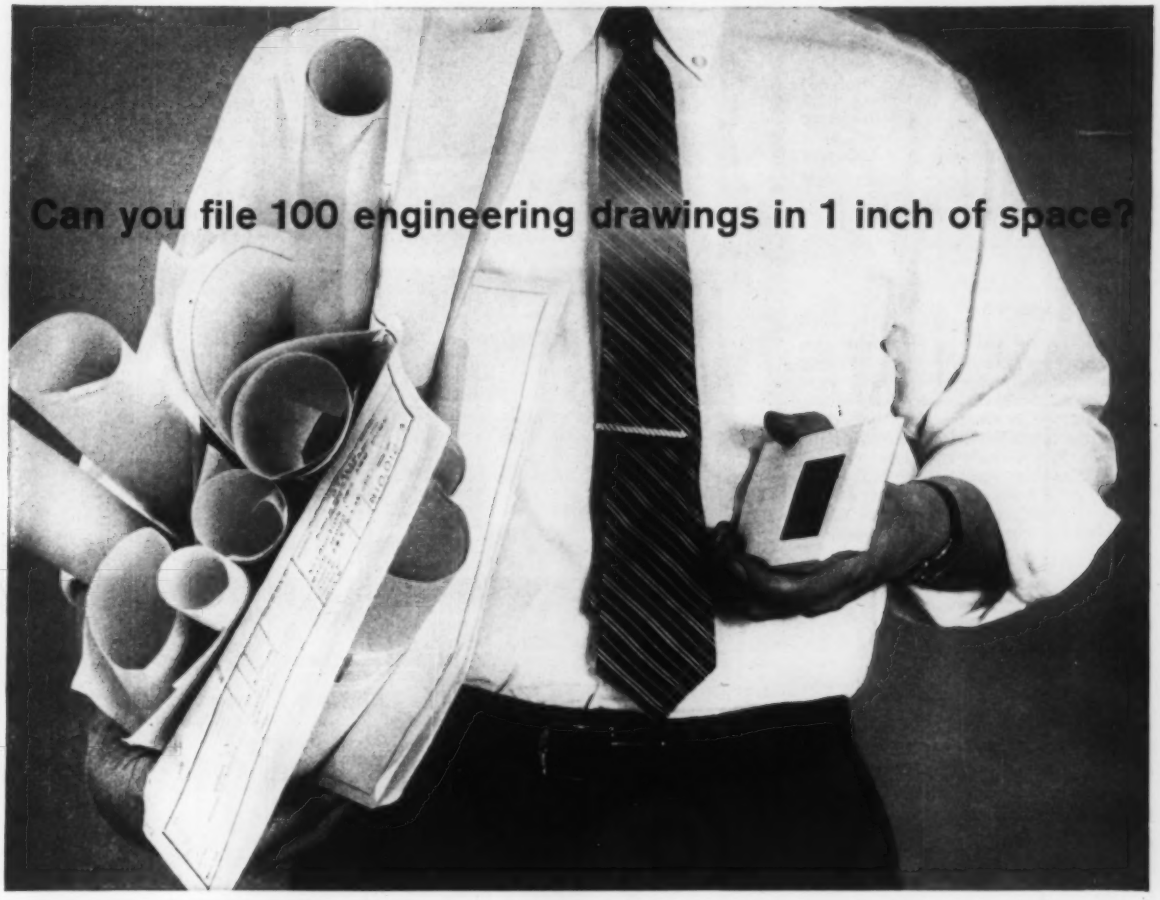
3. The speaker has no way of knowing exactly what "picture" he conveys to the mind of the listener. He is no more capable of exactly communicating an idea to the listener than the listener is to him. Therefore, he cannot even check with his listener to ensure perfect accuracy.

4. The mind avoids detail. It cannot assimilate a great amount of detail in a short time. For example, a person looking out of a moving automobile sees fields, trees, and vegetation. He does not see 63 trees having a total of 7834 limbs, and 8,640,392 leaves. He sees only a "lot" of green trees. This mental tendency to avoid specifics hampers accurate communications.

5. People assume too much. When in their own minds they clearly understand a concept, it becomes quite simple to them. As a result, they frequently think it is simple to a listener too, when in fact it may prove exceedingly difficult to grasp.

6. Most people resist the reading of written instructions. Accumulated evidence supports the belief that most people resort to a trial-and-error procedure before following written instructions.

7. Often people who have only a hazy concept of what they would like to communicate attempt to impart ideas to others. If in their own minds they have no sharp image, it is almost impossible for them to convey a clear idea to others.



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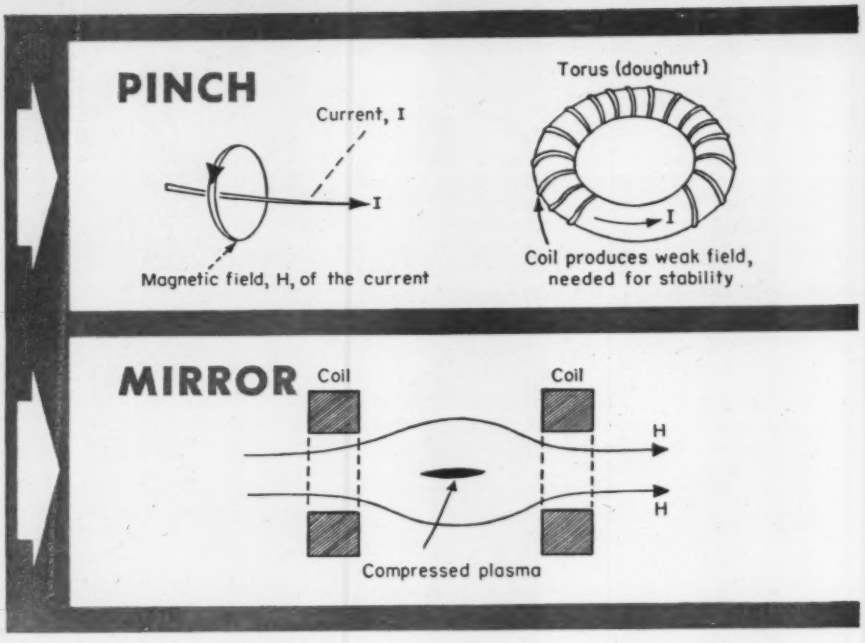


Pinch-discharge technique uses electromagnetic field of moving plasma to compress plasma along centerline of the tube and away from the enclosing walls. Coils outside the chamber produce weak field to stabilize discharge. As the discharge automatically pinches itself down to a smaller diameter, the gas in the current channel gets hotter and hotter. The pinch technique is under study in laboratories throughout the world.

Magnetic mirror uses long straight tube surrounded by external coils. Current through the coils sets up magnetic field compressing the plasma. Extremely strong fields, set up at each end of the tube, bunch plasma currents together like tying the ends of a bundle of wires. Hence, any plasma reaching either end is reflected back toward the center of the tube. The mirror technique is under study by the University of California.

Head of AEC Fusion Research Describes

Four Routes to

THE SECOND International Conference on Peaceful Uses of Atomic Energy may not be so peaceful. At Geneva, Switzerland, this September, scientists will report progress in the hotly contested race to obtain economical power from thermonuclear reactions.

Among subjects of 2300 technical papers, U.S., British, and Soviet efforts to tame fusion power are bound to attract the most interest. And while papers are being formally presented at Geneva's Palais des Nations uptown, U.S. and Soviet exhibits at the Palais des Expositions downtown are certain to include actual exhibits of fusion progress.

In preparation for Geneva II, AEC spokesmen recently revealed three approaches to fusion power, besides the "pinched-discharge" method which was unwrapped for public view last January. With the quietly optimistic statement, "There is general belief in the American laboratories that the ignition temperature will be achieved within a few years," Dr. Arthur E. Ruark, head of the Commission's thermonuclear Project Sherwood, summarized newly announced progress in the field.

Three goals

The experimental work in the Sherwood program is concerned with so-called plasma—very dilute and very hot gas, confined by strong magnetic fields. It has three long-range goals: 1. To bring plasma to ignition temperature. 2. To obtain a thermonuclear reactor yielding net power. 3. To make an economic power producer.

Ignition temperature

The term "ignition temperature," warns Dr. Ruark, lends itself to misinterpretation. It is not strictly correct to apply the word "temperature" to plasmas produced in laboratories. One trouble is that the plasma is not a simple gas. It is made up of electrons and positive ions, and the average energy of the two types of changes can be quite different. The word "temperature" as used by the AEC refers to the energy of the ions, which are nuclei of heavy hydrogen.

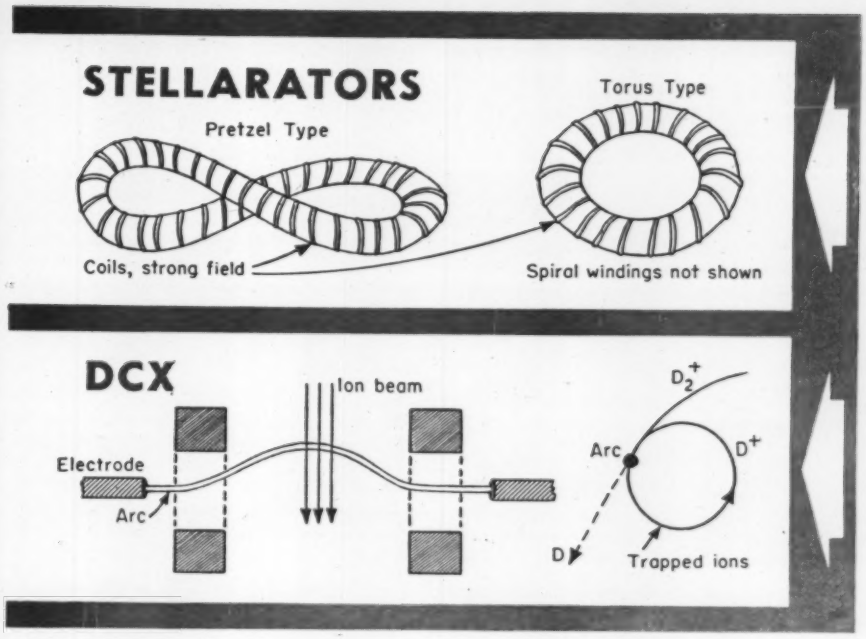
Fusion vs thermonuclear

Strictly speaking, the terms "fusion" and "thermonuclear" reactions are not entirely synonymous. A fusion reaction results when two ions collide and fuse, releasing a great amount of energy. A thermonuclear reaction occurs only when two ions collide and fuse in a uniformly hot gas.

But even in a very hot gas (plasma), collisions which result in fusion are rare. Most simply result in an exchange of energy between two ions similar to the collision of two billiard balls. A uniformly hot gas greatly increases the possibility of mass fusion reactions. Individual, scattered fusion reactions have for many years been producible in atom smashers. But only in recent years, with the development of methods for heating plasmas to uniformly high temperatures, have steps been successfully taken to produce actual thermonuclear reactions.

Four routes

To date, no country has produced a successful thermonuclear reaction, in which plasma is heated to a temperature of many millions of degrees and neutrons are emitted for a sustained period. But at least several



Stellarators use magnetic pumping technique to reach high plasma temperatures. Because under these conditions the gas would drift toward the walls, the first stellarators were designed like pretzels. Later, it was found that good gas confinement could be achieved in the torus form by ingenious tailoring of the magnetic field. Both methods are under study at Princeton.

DCX approach uses a confinement-space filled with superhot deuterium ions. The deuterium molecular ion (D_2+) is broken up by a high-current arc into an atomic ion ($D+$) and a deuterium atom (D). The atoms escape, but the hot ions are forced by the confining magnetic field of the mirror machine to circulate in smaller orbits. This work is carried on at Oak Ridge.

Thermonuclear Reaction

countries report success in producing and maintaining quite high temperatures of a plasma of light nuclei and in containing the plasma for brief but appreciable lengths of time. Whether or not significantly longer containment and much higher temperatures have been achieved remains to be revealed at Geneva II.

AEC statements reveal four techniques aimed at achieving the thermonuclear reaction.

1. In the pinch method, tremendous currents are passed through the gas. The magnetic forces of the current constrict the plasma toward the centerline of the tube, or in other words, the current "pinches" itself, with great increase in the density and temperature of the gas. Although straight tubes are often used in studying the phenomena, the principal effort involves the use of doughnut-shaped tubes.

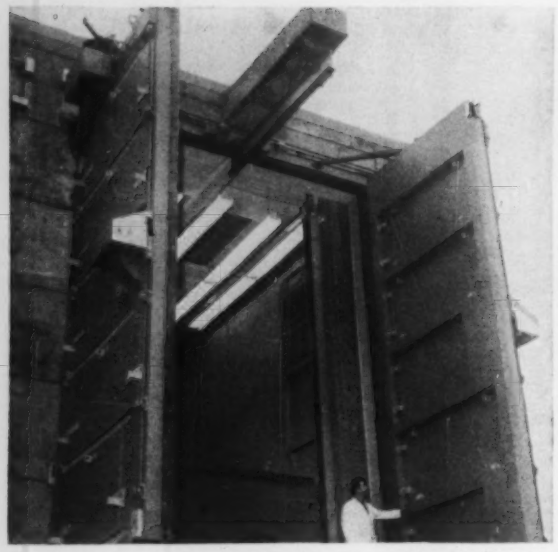
2. In the mirror program, energetic ions (and accompanying electrons) are injected into a strong field set up by two large coils. At first, the ions run on spirals nearly at right angles to the field. The current through the big coils is then increased. This squeezes the hot gas. In different designs, it is possible to squeeze the gas radially, and to push its particles together along the axis. It is also possible to push the gas from one chamber to another.

3. In the stellarator, cold gas is confined by a strong magnetic field. First a small current is passed through the gas, and then a larger one is caused to flow by transformer action. This brings the gas to a temperature greater than 1 million C. Because electrical resistance of the gas falls too low to permit further heating by electric current, the gas is then shaken with very strong alternating magnetic fields. This heating process is called magnetic pumping.

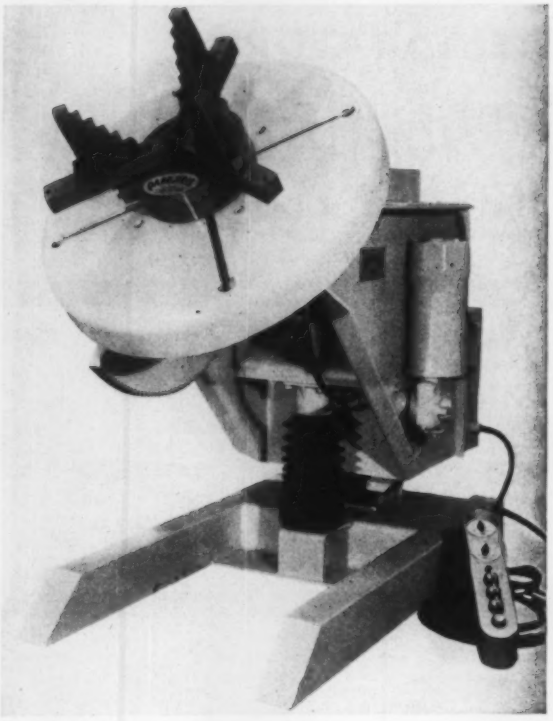
4. In the DC Experiment, or DCX, a confinement space is filled with ions of much higher energy then the ignition energy. When molecular ions are introduced into the extremely hot plasma, each molecular ion breaks up into an atomic ion (a deuteron) and an atom of deuterium. The atoms escape, but the hot ions are caught in smaller orbits and circulate in the confining magnetic field. So far work on this method has been done with continuous injection into mirror coils fed with DC current.

▶ Future plans

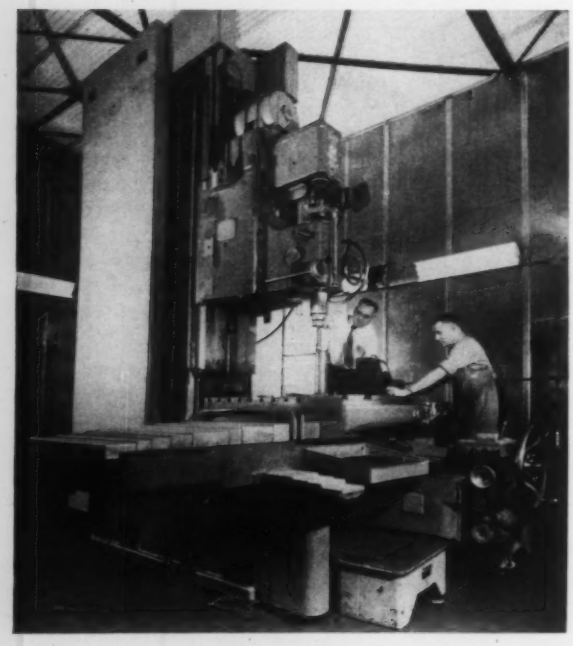
Future plans, according to Dr. Ruark, rest on the question of stability of very hot plasmas. This question may eventually single out one method for approaching the thermonuclear reaction, or a few methods, in preference to others. The Model C complex of equipment at Princeton is expected to come into operation in 1960. It provides larger and more powerful devices for the Princeton group. Similarly, the other groups steadily introduce larger power sources and new models of their devices. "So far as we can see now," said Dr. Ruark, "there are no shortcuts in this lengthy process of research and development."



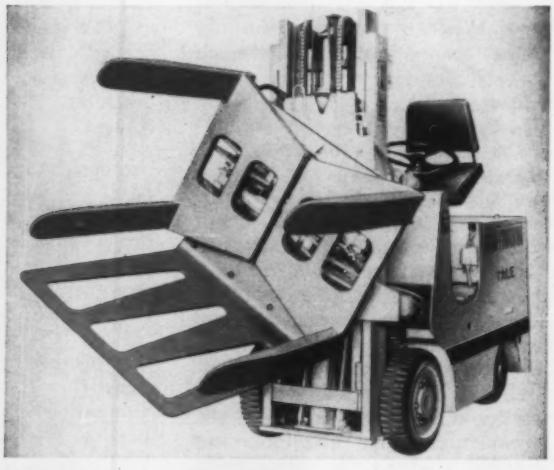
BLOWOUT DOOR PANELS will reduce explosive damage—if necessary—in Wright Patterson AFB Aeronautical Research Laboratory. Tests in the Lab are concerned with detonative combustion characteristics of unstable supersonic and hypersonic fuels. Controlled detonations are expected to produce pressures of 3000 atmospheres in the ramjet test equipment—and it is anticipated that any systems failure would result in violent explosions. The heavy, sound-reduction doors were built by Jamison Cold Storage Door Co.



ARC WELDING IS AUTOMATIC with this 3000-lb capacity welding positioner. It was designed for fast welding of various diameter cylinders. Table speed, workpiece diameter, and welding speed are correlated by the control system. Operator merely sets two dials on the control station, one for workpiece diameter, the other for welding speed in inches. The table then rotates at proper rpm. The new machine was designed and built by Pandjiris Weldment Co., St. Louis, Mo.

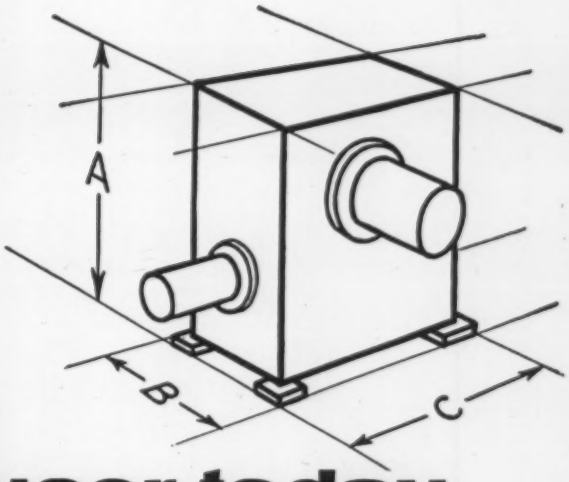


PRECISION IS NOT SACRIFICED by the size of this new Pratt & Whitney jig borer. Claimed to have the largest workpiece capacity of any borer in existence, the 26-ton unit will bore to the center of an 80-in. diameter workpiece, and maintain vertical alignment to 0.0001 in. over its entire 64-in. travel.



INVERTING LIQUID STORAGE CONTAINERS, to prevent "settling out" in stored paints, soaps, and chemicals, is the job of this new Yale & Towne lift-truck attachment. Lower pair of forks fits into pallet on which containers are stored. Upper pair positions empty pallet on top of load. The attachment then rotates 180 deg. Side plate, between forks, prevents load slippage from between pallets during rotation.

Do-It-Yourself...



Let's design a speed reducer today

So you can't find a speed reducer to fit your latest brainchild without ruining the design? Doggone manufacturers all build reducers too big to fit into those few cubic feet you've got left for the reduction unit back behind the double-ended dingbat?

Revolt! Design your own! Show 'em!

By George, design it yourself and it'll fit. How? Well, you know your size limits. Draw the biggest box that'll fit the space and you've got your reducer housing specifications.

Now you need gears that will (1) transmit the needed horsepower under all operating conditions, (2) provide the ratio your machine requires and (3) fit the space that's available. You'll soon discover that there are limits to what gears can do in transmitting horsepower. The cheapest answer is parallel shaft helical gears. If they'll fit you're in clover. But they take the most room, especially when you're out of the fractional hp range. The right angle worm and gear combination is the most compact drive arrangement.

Here again you have a choice. Cylindrical worm gearing is often used, and if it'll do the job, is worth consideration. But it's not the most compact possibility. The best way to shrink gears and still carry the load is the double-enveloping worm gear design. Both worm and gear are throated and the two literally wrap around each other. This brings center distance of the two shafts closer together and you can put them inside smaller housings.

Does this reduce load capacity? No sir! You can carry the same load with center distances up to 33% smaller than those of cylindrical worm gears. Or use the same center distance and carry a greater load. Will these gears hold up in operation? Sure, if you beef up the teeth, the bearings and the housing. Use straight-sided worm and gear teeth and you'll get all the strength there you'll ever need. Use large taper roller bearings with real B-10 life. Use a reinforced, heavy wall housing that won't distort under load. Put fins on it for added cooling and increased thermal horsepower capacity to meet your needs. Now, put the whole thing together and you've got a speed reducer that's a dilly.

Designing your own speed reducer give you a headache? Looking for an easier way? There is one. Someone's already done exactly what you're talking about. You can order that compact speed reducer right off the shelf. Where?

Cone-Drive Gears, that's where!

Yes sir. They stock double-enveloping worm gear speed reducers from fractional to 665 hp. Standard ratios from 5:1 to 70:1 in about 15 increments, all interchangeable in any type housing of a given center distance. Worms over and worms under. Gear shafts vertical, too. Single- or double-extended output shafts, or shaft mounted. Over 200,000 combinations possible. Wow! Just about anything you want.

Better get Cone-Drive's new speed reducer catalog that details everything. Ask for Bulletin CD-218. Cone-Drive Gears, Div. Michigan Tool Co., 7171 E. McNichols Rd., Detroit 12, Mich.

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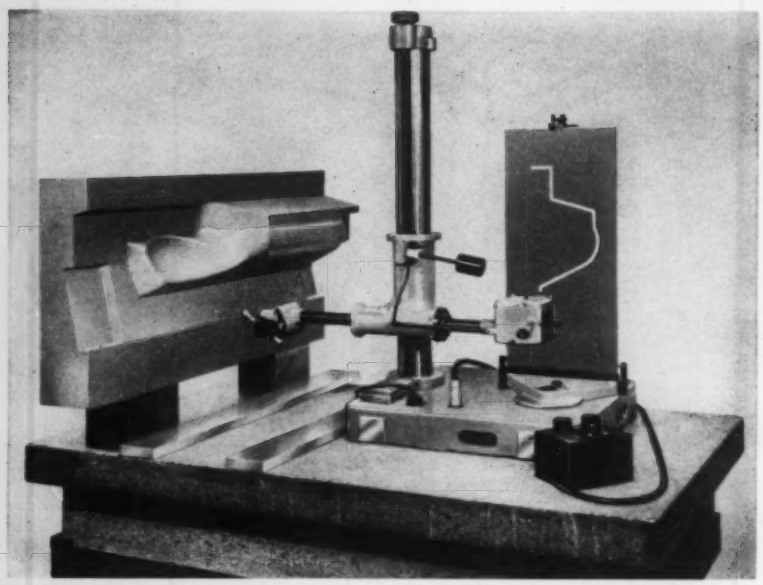
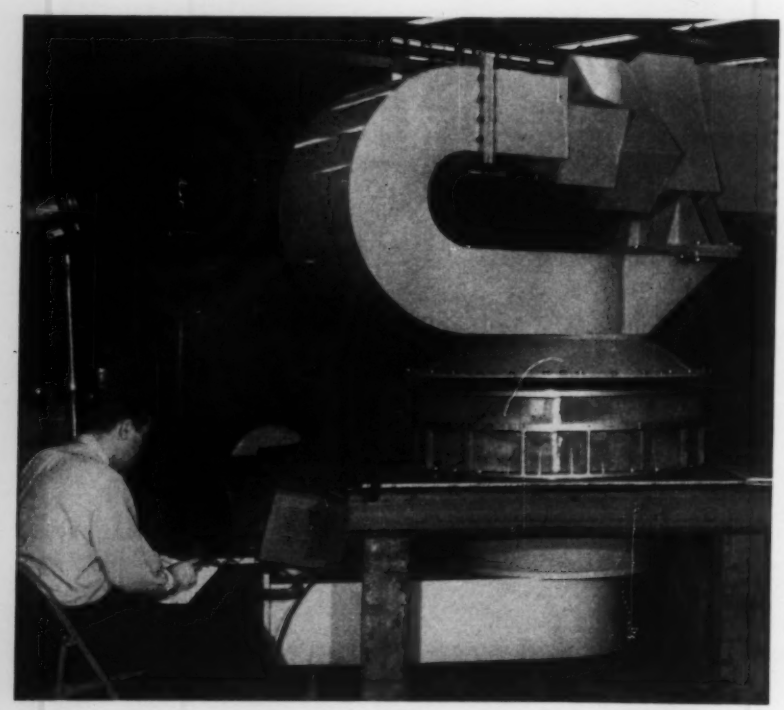


NONDESTRUCTIVE SECTIONING of contoured parts is made possible with this new contour transcriber. The unit traces contours of master patterns, models, dies, molds, and similar parts on specially coated glass, which can be retained as a permanent record. Traces can be made of exterior and interior part contours, top and bottom halves of a die, and mating parts. Traces are measured by determining *x-y* co-ordinates on conventional contour projectors, by comparing with a grid, and by comparing to a master outline or reticle. Called an OGP Contour Transcriber, the new device is a recent development of Optical Gaging Products Inc., Rochester, N. Y.



GIANT ROTARY JOINT for waveguide—the largest ever made—on test at Special Products Div. of I-T-E Circuit Breaker Co., Philadelphia. This aluminum joint, 6 ft high and 4 ft in diam, will carry 80 megawatts of power from transmitter to rotating antenna in uhf radar.

Needed: New Fuels to Double Car Engine Compression Ratios

Engineers Beat Knocking, But Rumble Is on the Rise

ATLANTIC CITY, N. J.—How much higher can auto engine compression ratios rise?

Based on experiments with seven V-8 modified production engines ranging from 9-to-1 to 25-to-1 compression ratio, two GM research engineers gave an answer to the question at a recent SAE meeting.

D. F. Caris and E. E. Nelson said present-day engines would give miles-per-gallon dividends up to approximately 17-to-1 compression ratio, providing that higher octane fuels can be supplied at a reasonable cost. They found that an engine's thermal efficiency "peaked" at the 17-to-1 level. Present-day engines average 9.5 to 1.

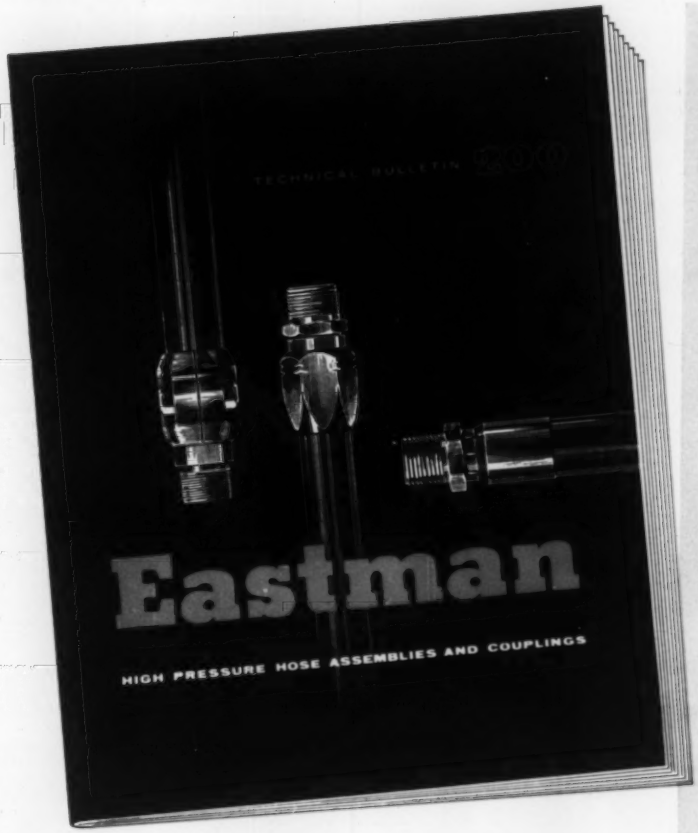
The 17 to 1 ratio appears to be the limit with engines based on today's designs, because of a delay of the combustion process or the burn of the air-fuel mixture in the engine combustion chamber.

In their experiments, Caris and Nelson used standard 324 cu-in. displacement engines with modified combustion chambers. Experimental fuels permitted operation at the higher compression ratios.

Test results don't imply that 17-to-1 compression ratio is a fixed ceiling for future automotive engines, but by all indications this is a ceiling for present engine designs.

Meanwhile, at the same SAE session, another GM researcher, W. M. Wiese, declared that, "Further rises in automotive engine compression ratios are likely to be limited by 'rumble,' unless changes are made in the chemical composition of fuels." Rumble was defined as a low-pitched thudding noise (in the engine) which is different from knock, but is associated with combustion.

Wiese suggested changes in the aromatic (benzene) content of fuels and the use of certain phosphorus additives. The additives help control the ignition of the air-fuel mixture, apparently by modifying combustion chamber deposits that accumulate when a car has been used for suburban driving. They also permit higher engine efficiencies through higher compression ratios.



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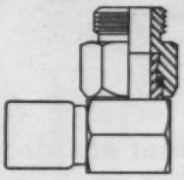
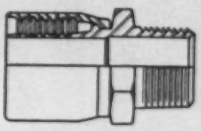
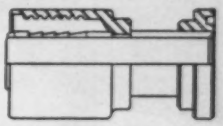


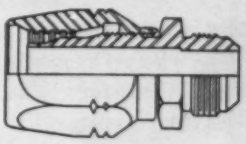
Swivel "O" Ring Male Couplings are available in 45° and 90° angles. Specifications on Page 13.



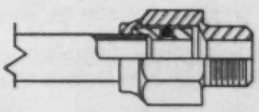
Permanently Attached Couplings for 2-wire braid hose. Specifications and Details on Page 10.



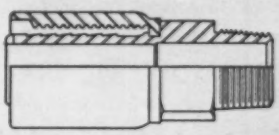
Permanently Attached Flange Head Couplings and Inserts from 0° to 90°. See complete list on Page 21.



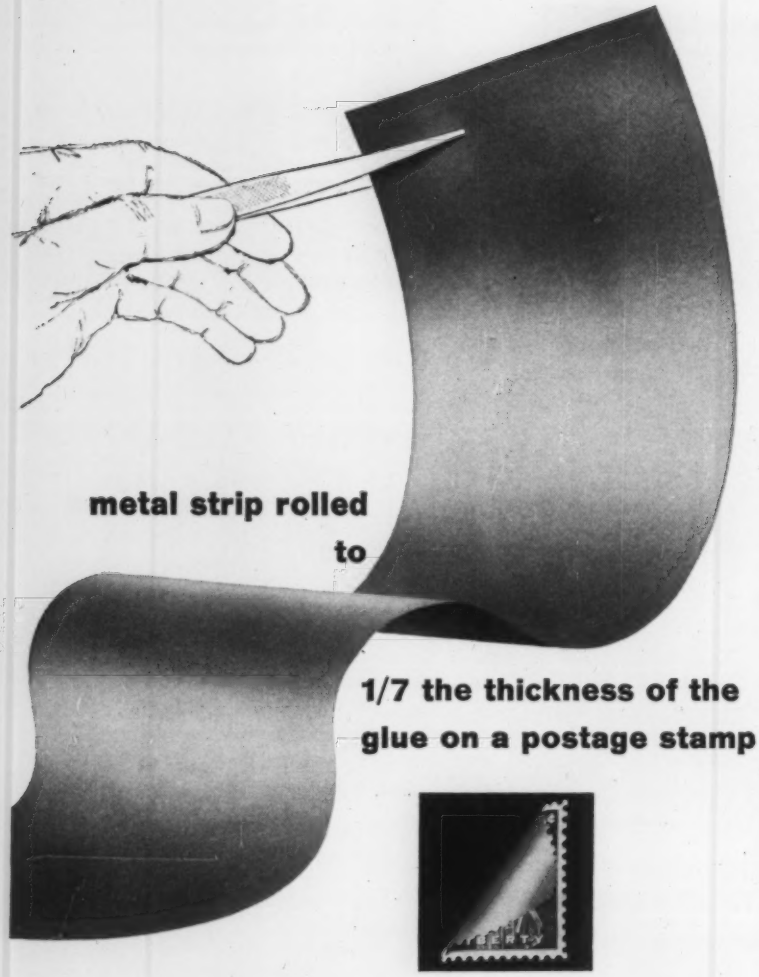
2-Piece Reusable Couplings for all high pressure hose. Used for pressures up to 5000 lbs. See Page 25.



Swivel Male Tube Nut "O" Ring Assembly used on formed tubing—described on Page 30.



Permanently Attached Couplings for **Extreme** High Pressures up to 7000 lbs. working pressure, Page 12.



Here is metal strip—available in virtually any alloy—produced in thicknesses ranging from .010" to .0001". (The glue on a stamp measures .0007".) Many of the miniaturization problems facing designers are being solved today by this ultra-thin strip and foil from the Precision Metals Division of the Hamilton Watch Company.

When product emphasis is on compactness and lightness, Precision Metals Division strip and foil will meet your exact mechanical, magnetic and physical specifications. For production orders or the development of new designs, this ultra-thin strip is available in any quantity. Special alloys to your own specification can also be made and furnished in the form you require.

A new 8-page facilities booklet illustrates and describes the operation of the Precision Metals Division, and shows how your precision metals problems can be solved practically and economically. Write on your letterhead today to Dept. MD-6.

Hamilton Watch Company

Precision Metals Division / Lancaster, Pennsylvania

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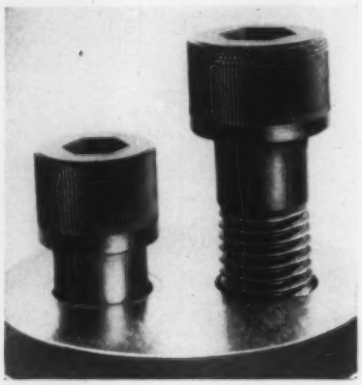
Better Head for Cap Screws Improves Fastening Efficiency

JENKINTOWN, PA. — Redesign of a 25-year standard—the socket-head cap screw—has produced a more effective ratio between head bearing area and bolt tensile strength. The result: Much fuller realization of inherent fastener strength.

According to Standard Pressed Steel Co., who developed the new concept, 7 out of 10 cap screws—between $\frac{1}{4}$ and 1 in. in diameter—have undersize heads. Furthermore, no standard relationship exists between head bearing area and tensile strength—it varies widely between fasteners.



Loading effect of two socket-head cap screws—one conventional, the other with a new head design. Each was loaded to 60,000 lb (100,000 psi in bolt thread). Conventional screw indented to 0.012 in., while the larger head did not indent. Brinelling caused by conventional screw can dissipate up to 100 per cent of the preload of a fully loaded screw of this size.

In the new SPS design, head diameters have been uniformly scaled up to hold bearing stress to 80 per cent of the applied axial tensile load on the bolt.

Typical improvement cited for the new cap screws: The conventional $\frac{7}{8}$ in. diameter screw can be loaded to 20,300 lb before indenting cast iron or machinery steel. By comparison, the new head design on the same body diameter can be loaded to 47,500 lb before brinelling occurs.

As additional advantages, fuller utilization of inherent fastener

Circle 417 on Page 19

Cap Screw Dimensions: Old and New

Screw Size (in.)	Head Diameter (in.)		Bearing Area (sq in.)	
	Old	New	Old	New
¼	0.375	0.375	0.041	0.041
5/16	0.435	0.468	0.047	0.072
⅜	0.560	0.560	0.102	0.102
7/16	0.623	0.656	0.116	0.148
½	0.748	0.748	0.118	0.118
9/16	0.810	0.843	0.209	0.247
⅝	0.873	0.973	0.203	0.305
¾	0.998	1.125	0.223	0.432
⅞	1.123	1.312	0.254	0.594
1	1.310	1.500	0.364	0.785

strength results in the use of smaller or fewer fasteners, washers are eliminated in many applications, and greater use of socket-head cap screws is permitted, particularly in softer materials.

Bright New Quartz Lamp For Light-Sensitive Jobs

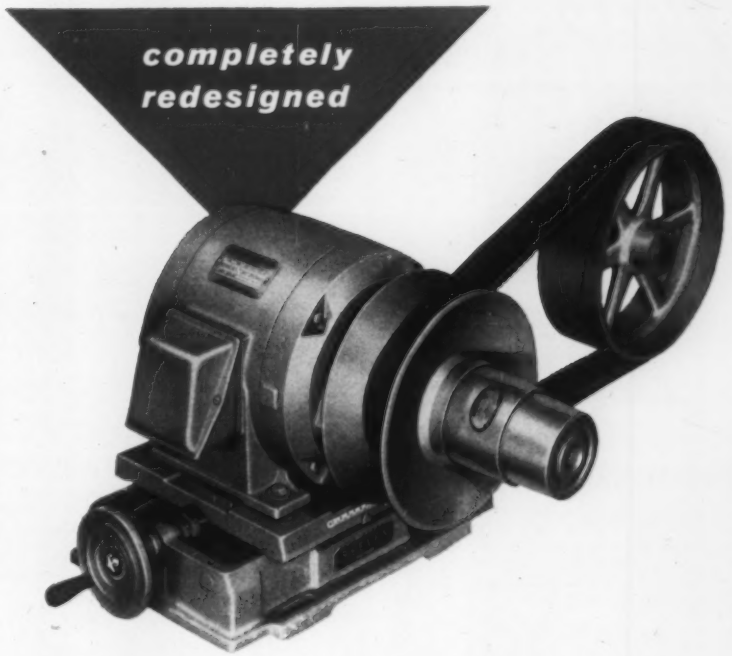
NEW YORK—A tubular quartz lamp, designed primarily to expose slow-speed photo-sensitive materials, promises substantial savings in power, air conditioning and maintenance costs according to General Electric Co.

Called the Pulsed Xenon Arc lamp, the new unit is expected to find use in the printing and publishing industry—burning in lithographic plates, color separation work, copy-board work—and in the electronics industry, where photo-sensitive material is used in making printed circuits.

The PXA lamp operates with a radar-like pulsing effect, flashing on and off 120 times per second (one pulse for each half cycle of the line frequency). Flash duration is about 0.001 sec.

The lamp comes in lengths ranging from 3 to 36 in. and is about ½ in. in diameter. It can be turned on and off with no warm-up time, maintains a high wattage concentration, making it a highly concentrated light source, and is adaptable to highly efficient reflectors. Under typical operating conditions it has a life expectancy of 50 hr.

The pulse-producing ballast is an uncomplicated device, using no moving parts or electron tubes, and the ballast circuit itself is similar to that used in radar power supplies, according to GE engineers.



REEVES® *Vari-Speed MOTOR PULLEY*

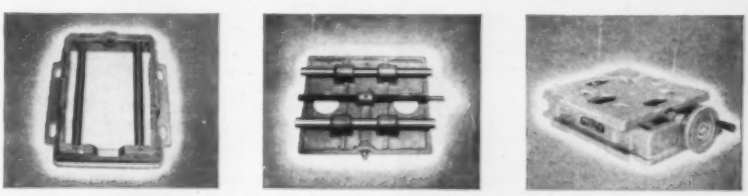
Here is variable speed control in its most simplified form . . . variable speed control with new economy.

Disc assemblies have just three main parts: two smooth-face, cone-shaped discs; and the belt tension spring. There are no other wearing parts to give maintenance trouble. Compact disc assemblies available in nine sizes, ½ hp. through 15 hp., to fit both old and new NEMA motors.

Separately mounted countershaft assemblies are available. For complete information on sizes and available controls, write for Bulletin H36a-V582.

Split section view of sliding disc shows how REEVES "close grooving" maintains film of lubricant between hub length of fixed disc and bore of sliding disc. One lubrication point services entire disc assembly.

New precision bases Four compact sizes to accommodate old and new NEMA motors in ½ through 15 hp. Sturdy bases are specially manufactured to assure positive, easy adjustment and accurate speed control.



Base and motor slide rods manufactured for precision fit and true alignment. Fully-lubricated shifting screw and precision features provide easy shifting.

REEVES PULLEY COMPANY

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Columbus, Indiana

Circle 418 on Page 19

PUMP PROBLEMS?

WAYNE HAS THE ANSWER TO LOW COST OPERATION

RUGGED DUTY PUMPS

For truck mounting and other installations where operating conditions are unusually severe. Tapped for pipe sizes 1½" to 2"; capacities 35, 50 and 100 gpm. Flange type for pipe size 2½" to 4"; capacities 100, 200 and 300 gpm.

HAZARDOUS LIQUID PUMPS

Similar to standard models in appearance and construction. Can be furnished with any type of drive. Complete with relief valve. Listed under re-examination service of U.L.

STANDARD SERVICE PUMPS

Gear-within-gear rotary pump available in capacities of 5, 10, 18, 20, 30, 35, 50 and 100 gpm. Horizontal port may be on left or right side; also made with straight - through ports.

For complete information on all types of rotary pumps for handling liquids from volatiles to heavy asphalt with less maintenance and lower costs write for new data book and catalog to . . .

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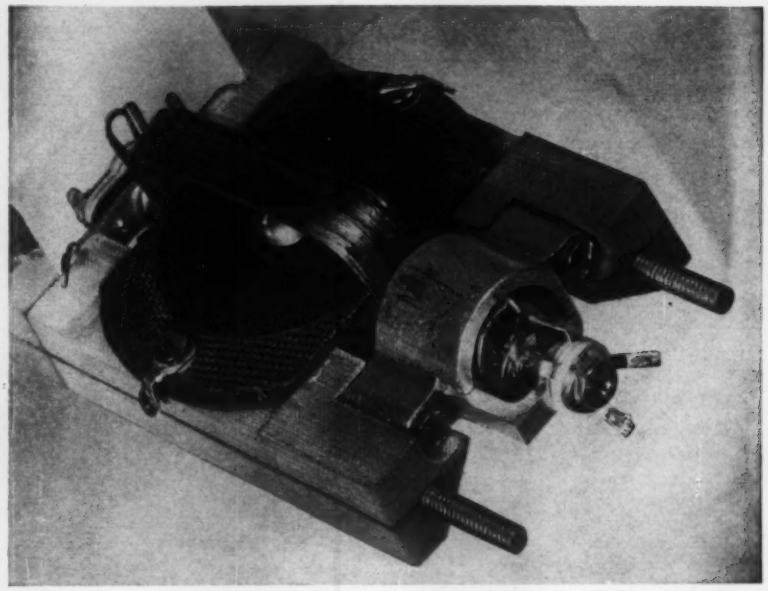
Wayne PUMPS

Circle 419 on Page 19



SINGLE-INSTRUMENT CONTROL of electrical power is the feature of this locking-contact wattmeter developed by Assembly Products Inc., Chesterland, O. Previously, wattage has been controlled less accurately by regulating either current or voltage. The new instrument consists of a standard dynamometer movement, left, with the voltage coil turning within the field of the stationary current coil. Core-magnet meter movement, right, is on same plane as the voltage coil of the wattmeter, and moves with it. The core-magnet movement supplies torque of 3 grams and locks the moving pointer of the wattmeter to a preset fixed pointer, closing circuit to control device.

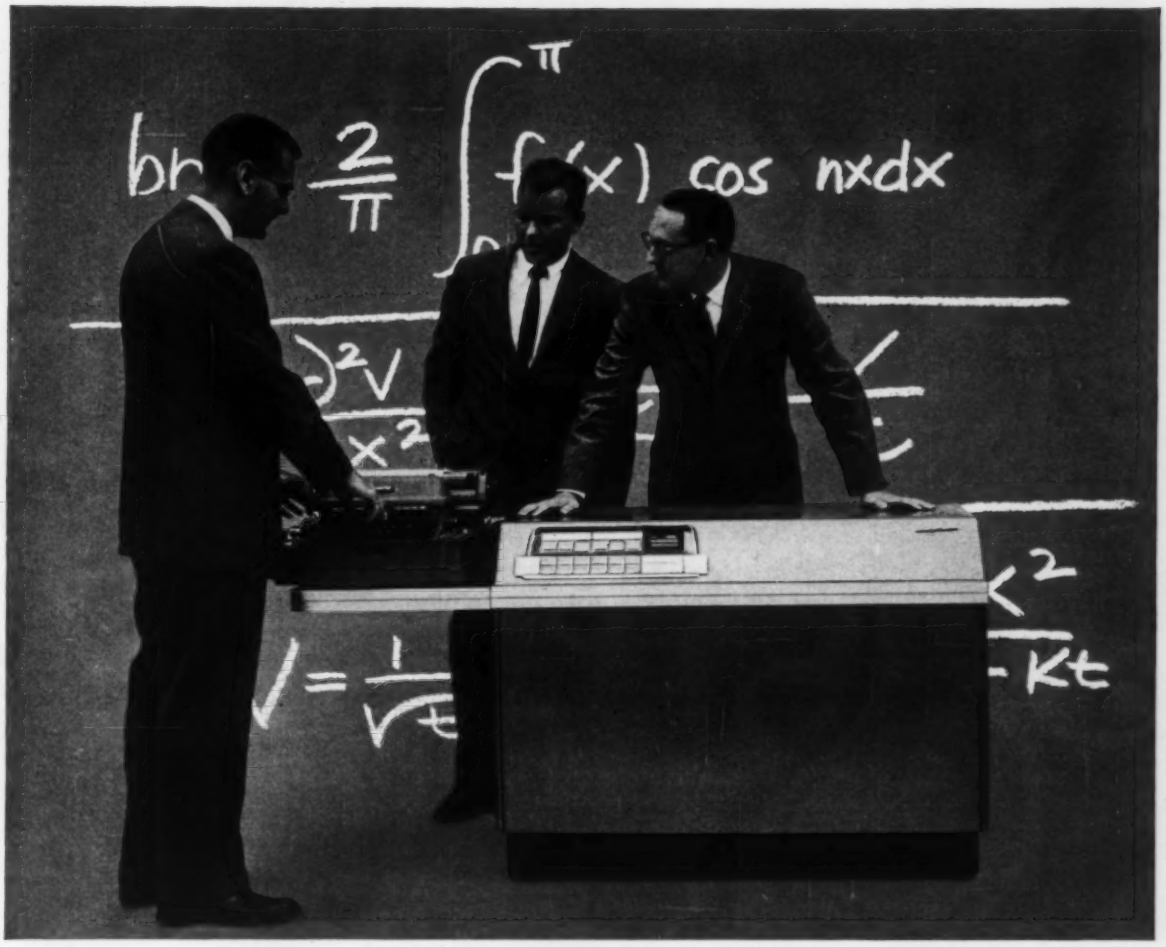
Signal Corps Adopts World's Fastest Typist

WASHINGTON—The world's fastest message printer and code puncher, hammering out messages at 750 wpm, will be able to rush high-priority messages to mobile command posts. Developed for the Army Signal Corps by Kleinschmidt Laboratories Inc., the device has no ordinary typing keys.

Instead, a whirling wheel rimmed with letters prints the high-speed messages. It spins at 3750 rpm. A tiny hammer slaps the paper against the type wheel each instant the correct letter comes into position.

It types out messages on $\frac{7}{8}$ in. paper tape at the same time that it punches out coded holes. Tape spews from the printer at the rate of $7\frac{1}{2}$ in. per second. The tape messages can be relayed to other points or can be printed in page form on the spot by automatic typewriters.

Combat teletype unit prints out messages 12 times faster than the average typist. It mounts on a jeep or truck teamed to a mobile forward-area communications center. On short notice, the entire center can be packed up, moved to a safe location, and operated again.



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Unusual capacity. Operating from a standard wall outlet, performing an almost unlimited range of calculations, LGP-30 gives you the flexibility of stored-program operation combined with speed, memory (4096 words) and capacity equal to computers many times its size and cost. Completely mobile, LGP-30 is easily wheeled from room to room, building to building.

Simple to operate and program. LGP-30 controls have been so thoroughly simplified that it may be operated with only minimum computer experience. Direct print-out of answers – no deciphering required. Programming is easily learned—even by non-technical personnel. Library of sub-routines, plus programs for a wide variety of applications, is available.

Wide range of applications. In addition to general design and system optimization, LGP-30 is currently being used for the refinement of estimates; computation of design parameters; specification of new product properties and capabilities; calculation of such data as reactance, load saturation curves, time constants, harmonics, torque-speed and vee curves.

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Circle 420 on Page 19

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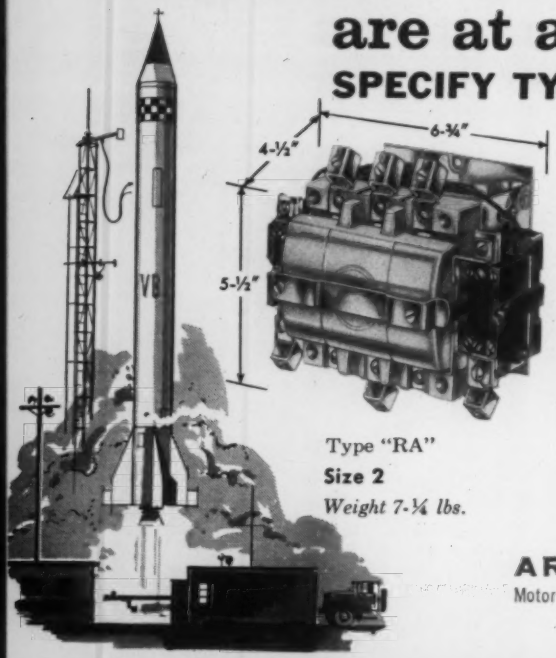

Type "RA"
Size 2
Weight 7-¼ lbs.

Launching, guidance, tracking and service equipment for rockets or guided missiles *MUST* pack the greatest possible performance capacity into the smallest possible envelope. That's why Arrow-Hart Type "RA" Starters and Contactors have been selected for so many rocket and missile projects . . . and so many other applications where space and weight savings are all-important. Far smaller and lighter than conventional types, Arrow-Hart "RA" Controls use advanced design with greatly improved mechanical efficiency to achieve superior performance and dependability. The modern Right Angle operating mechanism insures positive operation and provides increased resistance to unfavorable atmospheric conditions.

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Motor Controls • Wiring Devices • Appliance Switches • Enclosed Switches

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ARROW AH HART

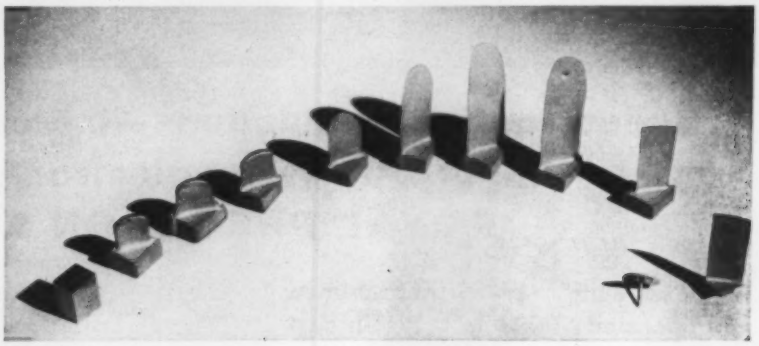
ENGINEERING NEWS

Aluminum V-8 Car Engines In Advanced Stage at GM

WARREN, MICH.—A series of experimental aluminum V-8 car engines, developed during a 6-yr research program at General Motors, have successfully passed laboratory and road trials. Hand-built, and not production prototypes, they weigh about 30 per cent less than standard engines of comparable displacement and horsepower. This represents the equivalent weight of one passenger per car.

The new powerplants are described as high-compression, high-output, liquid-cooled engines, higher in compression than conventional engines which average 9½ to 1.

Major obstacle in the research program, according to GM officials, was development of a suitable cylinder bore material at a practical cost. Chrome was used, but proved too costly. In addition, reproducibility and inspection of quality are inherently difficult with chrome.



ROLL AND COIN process, involving use of a hydraulic fixture fitted to a conventional press, forms an aircraft gas-turbine blade. Developed by General Electric Co., the technique is expected to result in a 50 per cent cost reduction on each blade. The process may consist of as many as 40 individual operations, including such steps as extrusion, rolling, coining, and trimming. The blade starts as a rectangular slug.

GM tested several aluminum alloys, "some old and some new," that have wear resistance superior to cast iron, according to L. R. Hafstad, GM research chief. Cost appeared to be about the same per pound of molten metal as the cost of common aluminum casting alloys. Several coatings were also tested ". . . which appear more desirable than chrome plate."

Overall objective of the program, of course, is development of lighter weight engines with better economy and performance. Beyond that, are the possibilities in manufacturing: Aluminum is said to be easier to work than cast iron.

Automated Library Soon? Memory's All Ready

Input and Output Are Problem Areas

SAN JOSE, CALIF.—Handing a magazine or a book to a machine and having it turn out a comprehensive index of the contents is a long way off. But the memory systems needed for automated technical libraries are ready and waiting, according to M. M. Astrahan, manager of systems research at IBM Research Laboratory.

Discussing memory systems before the Conference on Communication of Scientific Information, Mr. Astrahan said, "Memories will serve as indexes to the deluge of technical literature when the problems of input and automatic generation of classification information are solved." He pointed out, however, that memory capacity is currently ahead of the designer's ability to use it and much work remains to be done in this area.

Mr. Astrahan dealt with the problem of memories that will provide reference to millions of images of document pages: "For storing picture images, there is microfilm which can put several thousand frames on a 100-ft reel. At present, 100:1 reductions are possible for sheets containing typed text.

"This results in a storage density of 100 pictures per square inch. One thousand pictures per square inch is a reasonable goal for a practical machine. Devices which have been demonstrated include Minicards with a 60:1 reduction and 12 frames plus coding to a card about $\frac{5}{8}$ x $1\frac{1}{4}$ in., and the National Bureau of Standards system which provides direct access to any of the thousand frames on a 10 x 10 in. piece of film, which is a 100:1 reduction."

The most evident application of large memory to scientific communication involves communication by means of written information, as well as photos and drawings. According to Mr. Astrahan, large memories will help answer the questions of what is there and where is it, and will also help to carry out the orders, "get it," and "translate it."

Getting answers to the two questions, "What is there?" and "Where is it?" is probably the most pressing subject for study, he said. "Variations of this problem are called Information Retrieval, Literature Search, Indexing, and other similar names."

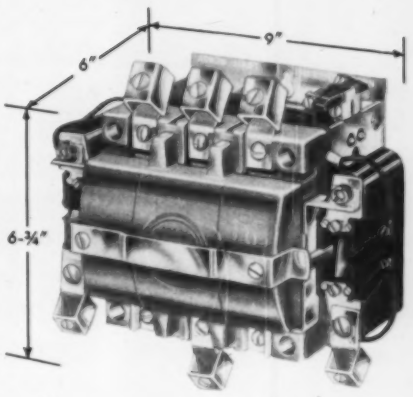
The problems described by these names, he said, cover a wide range of complexity. He cited examples. "The simplest kind of problem would be the following: Given a set of research reports, each defined by a unique number, find the location of the report corresponding to a specific given number. An example of the most complicated kind of question would be the following: What has ever been written concerning the photoconductive properties of materials in a specified incident radiation frequency range?"

MOTOR CONTROLS

SMALLEST Magnetic Starters Available!

Arrow-Hart Type "RA" Motor Controls feature the advanced design "Right Angle" mechanism, with the magnet operating through a simple bellcrank mechanism. This provides a mechanical advantage making possible a much smaller and lighter magnet which out-performs older, direct-acting types. As a result, size and weight are reduced by almost half, while performance, operating efficiency and dependability are greatly improved. Other important "RA" design features include extra-rugged silver cadmium alloy contacts with positively guided travel for perfect alignment . . . and straight-thru wiring for simplified circuit design.

Arrow-Hart offers you the *only* complete line of smaller, lighter motor controls including: NEMA Sizes 0 through 5, in across-the-line, reversing and two-speed starters and contactors.



Type "RA" Starter
Size 3
Weight 15-½ lbs.

Write for free 16 page booklet of Motor Control Wiring Diagrams: The Arrow-Hart & Hegeman Electric Company, Dept. MD, 103 Hawthorn Street, Hartford 6, Connecticut.

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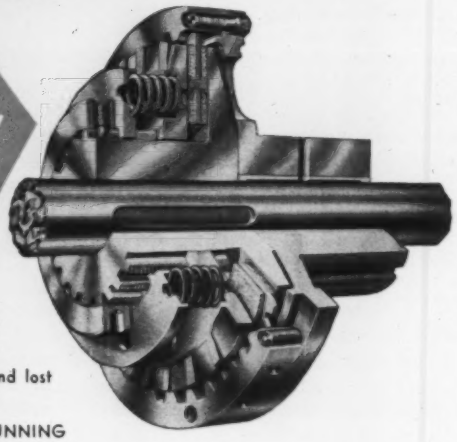
HILLIARD *Clutches*
FOR POWER CONTROL DESIGN

ADJUSTABLE
Slip Clutch



- PROTECTS against overload, jams and down time.
- RESUMES THE DRIVE AUTOMATICALLY after overload.
- ELIMINATES SHEAR PINS and lost time.
- ADJUSTABLE - WHILE - RUNNING feature is available.

Hilliard Slip Clutches are continuously protecting the drive on dish washing machines—printing presses—packaging machines—case loaders—foundry equipment— air filters—conveyors—overhead doors—and many others.
They maintain steady torque while permitting speed variation on fabric drying drums, steel strip slitters and similar equipment.

The adjustable-while-running types are used to maintain constant tension on rewind stands for paper coaters, textile machines, rope, steel and wire mills and for drive systems requiring overload protection but which must be disconnected at times.

WRITE TODAY FOR BULLETIN 300 WITH COMPLETE INFORMATION.

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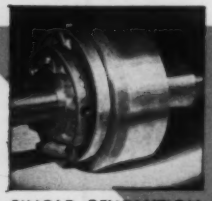
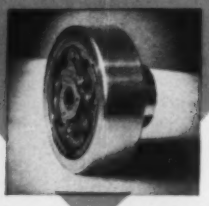
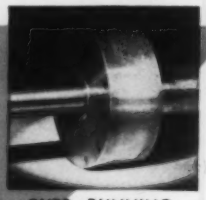


SINGLE REVOLUTION CLUTCHES for automatic accurate control —electrical or mechanical—of intermittent motion, indexing, cycling and cut-off.
Ask for Bulletin 239.

HILLIARD - TWIFLEX CENTRIFUGAL COUPLING for smooth, easy starting of any load automatically with overload protection and ability to accommodate shaft misalignment.
Ask for Bulletin CE-3.





OVER - RUNNING CLUTCHES for automatic instantaneous engagement and release on two speed drives, dual drives and ratchet, or backstop action.
Ask for Bulletin 231.

THE HILLIARD *Corporation*

MANUFACTURING CLUTCHES FOR OVER 50 YEARS

103 WEST FOURTH ST., ELMIRA, N. Y.

IN CANADA: UPTON • BRADEEN • JAMES, LTD.

Call High-Speed Landings No. 1 Problem for Tire Study

Class Other Problems As Everyday Routine

AKRON—Main research problem for aircraft tires is the extreme landing speeds to which they are being subjected. Goodyear Tire & Rubber Co. scientists report working on a great variety of problems, including tires for future atomic-powered aircraft, but class many of these as just routine.

The big problem is that guided missile tires must withstand landing speeds of 346 mph, and the company is now receiving inquiries in the 400-mph range, at which planes may be landing by 1960.

To show why increasing speeds of aircraft are tabbed as the number one problem area by tire designers, they point to basic performance statistics. An 18 x 4.4 airplane tire, for example, revolves 4800 times per minute at 230 mph. This is approximately three times as fast as the common electric motor turning at 1750 rpm. Standing waves—three to four per revolution—cause the tire to flex about 15 or 20 thousand times per minute. The considerable heat generated makes the tire prone to premature failures.

The company scientists have been exposing tires to nuclear radiation for two years, but claim this is just a routine problem, and conclude that tires of natural rubber or synthetic materials, when filled

"I lost my T-square."

with nitrogen gas, will do the job.

Other problem areas under study by the company are elimination or reduction of the standing wave which occurs with conventionally shaped tires, high loads and high-inflation pressures, and ability to withstand temperature extremes ranging from below − 65 F to 800 F.

Meetings

AND EXPOSITIONS

July 8-11—

Institute of the Aeronautical Sciences. National Summer Meeting to be held at the Ambassador Hotel, Los Angeles. Additional information is available from IAS headquarters, 2 E. 64th St., New York 21, N. Y.

Aug. 6-8—

American Institute of Electrical Engineers. 1958 Special Technical Conference on Nonlinear Magnetics and Magnetic Amplifiers, to be held at the Hotel Statler, Los Angeles. Additional information is available from AIEE headquarters, 33 W. 39th St., New York 18, N. Y.

Aug. 13-15—

Conference on Electronic Standards and Measurements to be held at the National Bureau of Standards' Boulder, Colo., laboratories. Sponsors are the American Institute of Electrical Engineers, the Institute of Radio Engineers, and the NBS. Further information is available from U. S. Dept. of Commerce, National Bureau of Standards, Washington 25, D. C.

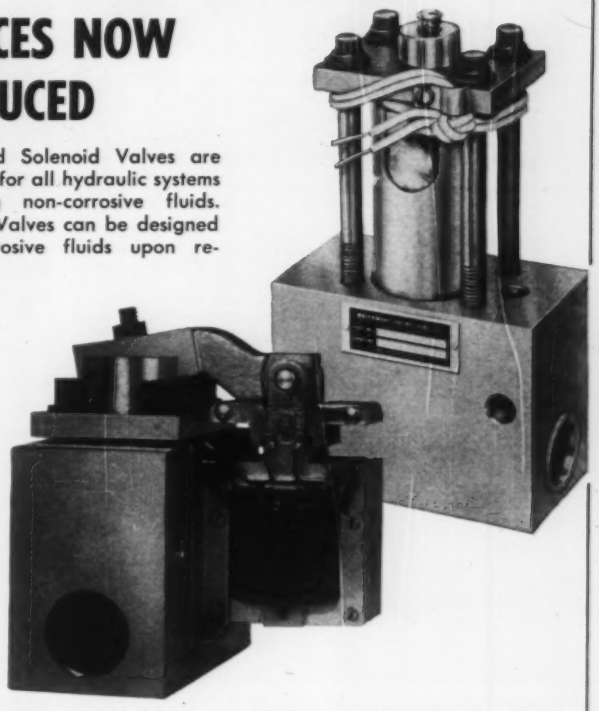
Aug. 19-22—

Western Electronic Show and Convention to be held at the Ambassador Hotel and Pan Pacific Auditorium, Los Angeles. Sponsors are the West Coast Electronic Manufacturers Association and the Institute of Radio Engineers. Additional information can be obtained from Don Larson, WESCON, 1435 S. La Cienega Blvd., Los Angeles 35, Calif.

SOLENOID VALVE

PRICES NOW REDUCED

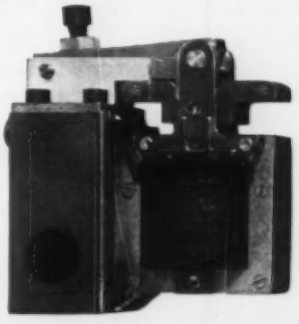
Standard Solenoid Valves are suitable for all hydraulic systems handling non-corrosive fluids. Special Valves can be designed for corrosive fluids upon request.



They have working pressures up to 3000 psi. They are designed for remote push button control of hydraulic systems. Poppet construction eliminates leakage.

Waterman Solenoid Valves are used in material handling field, Road Building Equipment, Presses and Box Machinery. Many applications in all types of Industry have found them dependable and inexpensive.

The impregnated coils are oil and moisture resistant and units can be mounted in any position. Available in 110-220-440 A.C. and 6-12-24-36 D. C.



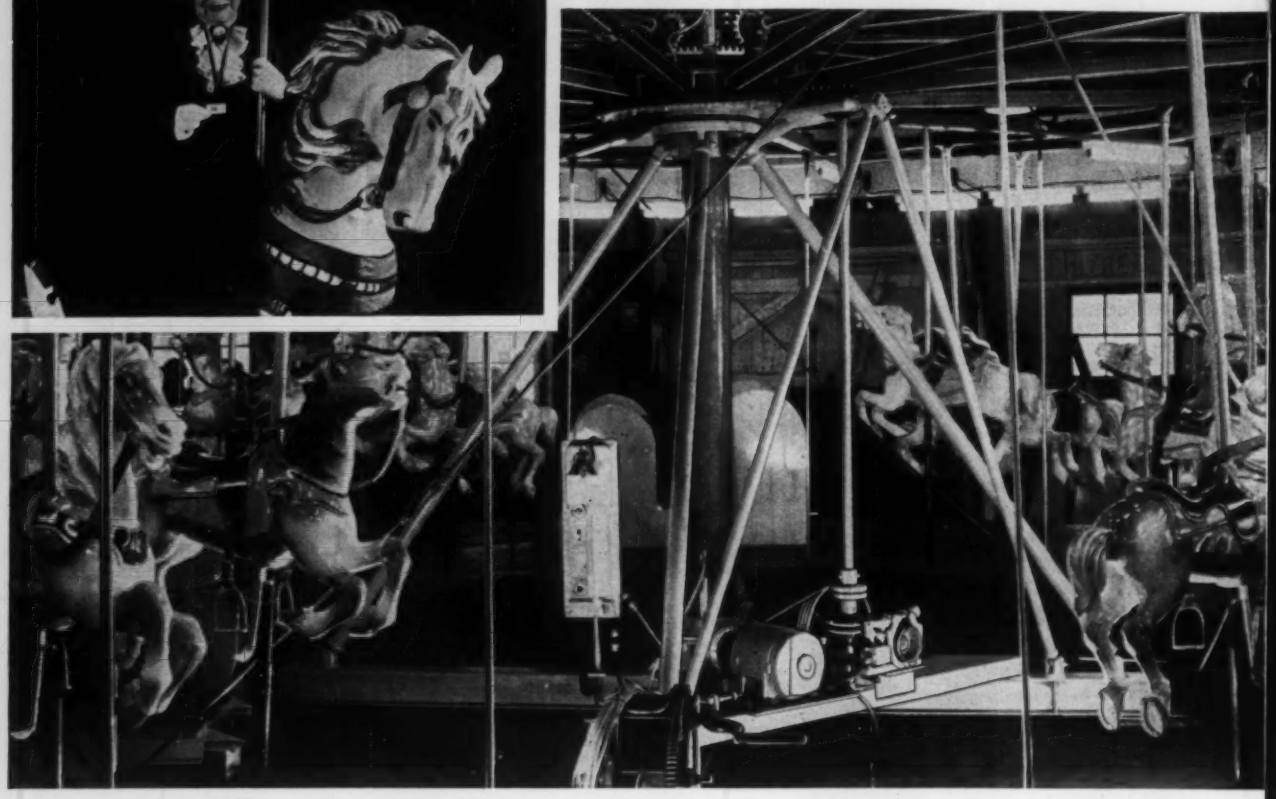
WRITE FOR LATEST SOLENOID BULLETINS

WATERMAN ENGINEERING COMPANY

725 CUSTER AVENUE · EVANSTON, ILLINOIS

Circle 424 on Page 19

Since 1880, Allan Herschell Company, Inc., North Tonawanda, New York, have created safe, appealing rides in the highly specialized field of engineering and constructing carnival and park amusements. Republic ELECTRUNITE is used extensively.



Meet severe design, engineering, service requirements with Republic ELECTRUNITE Mechanical Tubing

ROUNDS... SQUARES... RECTANGLES

Republic ELECTRUNITE® Mechanical Tubing offers many outstanding fabricating advantages in the highly specialized field of creating, engineering, and constructing carnival and park amusements. That is why the Allan Herschell Company, Inc., world's largest manufacturer of merry-go-rounds and amusement rides, specify ELECTRUNITE.

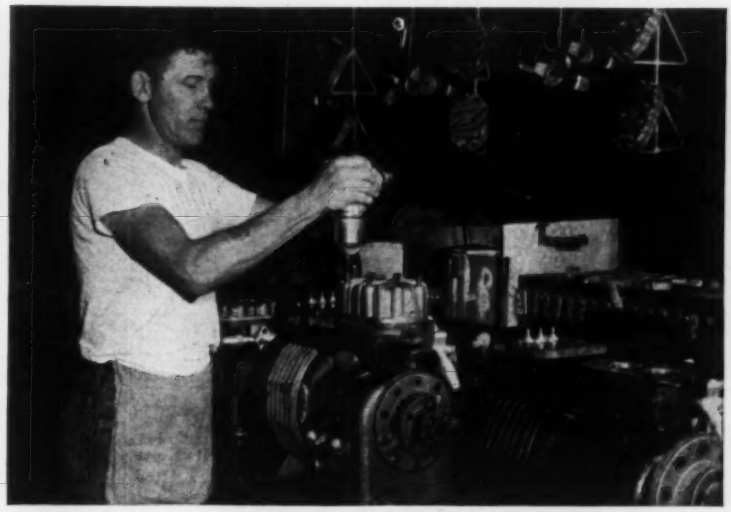
For example, Republic ELECTRUNITE 3" Square Tubing is used for the sweeps which radiate from the top of the merry-go-round. Horses and other equipment are suspended from these sweeps, as well as passenger loads.

ELECTRUNITE is strong, rugged, lightweight with high strength-to-weight ratios that assure safe, dependable day-in, day-out operation. Because of this lightness and strength, portable amusement equipment built with Republic ELECTRUNITE is easy and economical to set up, take down, and transport.

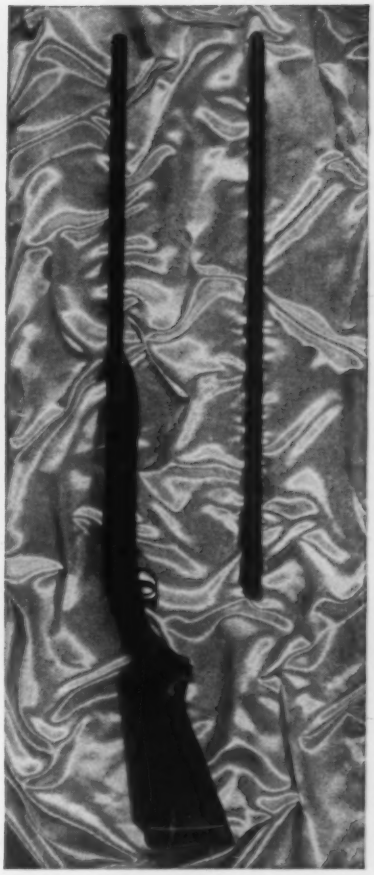
With Republic ELECTRUNITE, strength, weight, and safety are built-in because ELECTRUNITE is quality controlled from Republic mines, through Republic mills, to manufacturing. ELECTRUNITE is produced from highest quality flat-rolled open-hearth steel, welded by the exclusive ELECTRUNITE process—a continuous electric weld method that unites the wall under pressure without the addition of foreign or extra metal. Tests prove the ELECTRUNITE weld is as strong or stronger than the original base metal.

Republic ELECTRUNITE Tubing fabricates easily, economically, with uniformity. It is available in a wide range of sizes and provides uniform wall thickness, ductility, concentricity, diameter, and other physical and mechanical properties in flanging, flaring, bending, expanding operations.

Let Republic engineers help you select ELECTRUNITE Tubing to meet your many and varied needs. Call your Republic representative or write today.



SOLVE DIFFICULT ASSEMBLY PROBLEMS WITH REPUBLIC HEX HEAD CAP SCREWS, available in a wide variety of steel analyses including ENDURO® stainless, alloy, high carbon (heat treated) and low carbon in sizes suited to all types of precision assemblies. Diameters range from ¼ inch to 2 inches inclusive, with lengths to 12 inches. Fine or coarse threads are provided in each size and material—and other head styles can be furnished on request or order. Write today.



REPUBLIC COLD FINISHED BARS answer the problems of deep-hole drilling, reaming, bore-burnishing, and long-length turning operations for Harrington & Richardson, Inc., leading manufacturers of all types of small arms. Investigate the many Republic Cold Drawn Bar advantages for your operations. Send for data.

REPUBLIC ALLOY STEEL shrugs off fatigue, terrific torque, high impact load, in motor graders built by Adams Division of LeTourneau-Westinghouse Company. The grader's full-floating, two-section drive axle is made of Republic Hot Rolled 4340 Alloy Steel, resists fatigue, is able to take high torque without permanent set. Write today.

REPUBLIC STEEL

World's Widest Range of Standard Steels and Steel Products

REPUBLIC STEEL CORPORATION
DEPT.MD-5906
1441 REPUBLIC BUILDING • CLEVELAND 1, OHIO

I would like to know more about the following items:

☐ Republic ELECTRUNITE Mechanical Tubing
☐ Round ☐ Rectangle ☐ Republic Cap Screws
☐ Square ☐ Alloy Steel ☐ Cold Finished Bars

Name_____ Title_____

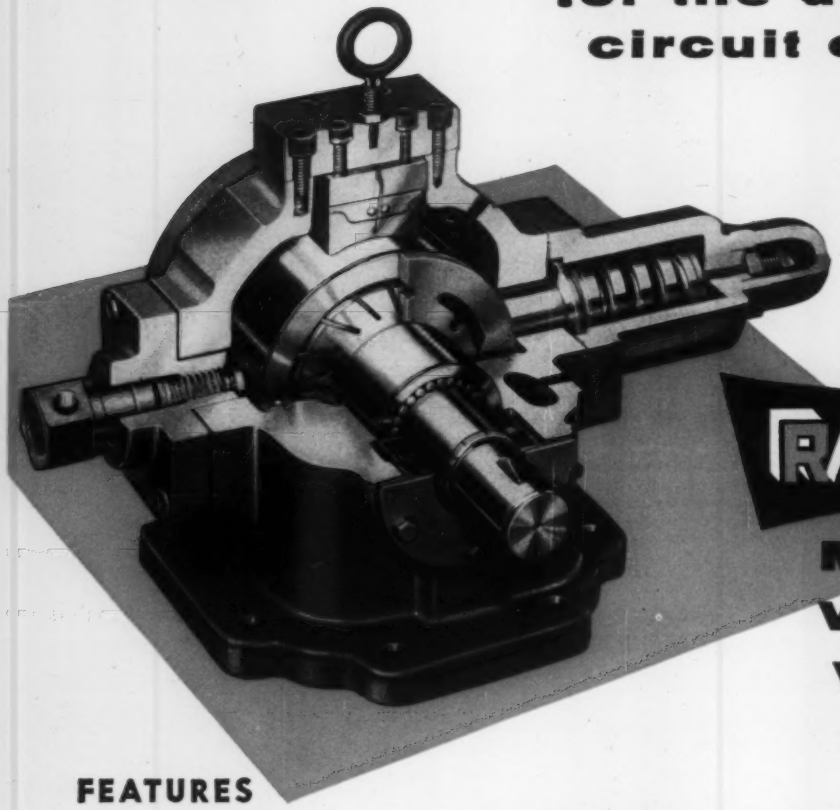
Firm_____

Address_____

City_____ Zone____ State_____

Circle 425 on Page 19

for the ultimate in circuit efficiency

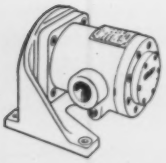


New RACINE® Model R Variable Volume PUMP

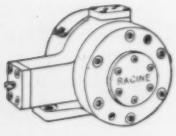
FEATURES

- **VARIABLE VOLUME DESIGN** simplifies the circuit. Relief valves with extra piping are eliminated.
- **AUTOMATIC BUILT-IN GOVERNOR** regulates volume of oil delivered to exact requirements of circuit. This feature reduces heat and saves horsepower.
- **VARIOUS BUILT-IN GOVERNORS** are available for electric, hydraulic or manual operation. Where needed, two pressure governors are provided.
- **THIS PUMP** is subplate mounted, result is simple installation and ready maintenance. Machine downtime is reduced.
- **DESIGNED FOR 40 GPM** maximum volume with built-in control to regulate flow to lower volume. Operating pressure 1000 PSI continuous duty, 1250 PSI intermittent duty.
- **SALES AND SERVICE OFFICES** in all industrial centers throughout the country. Write today for *new* fully descriptive bulletin.

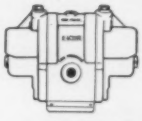
OTHER RACINE HYDRAULIC COMPONENTS "THEY WORK BETTER TOGETHER"



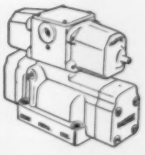
FLUID MOTORS



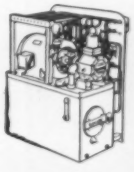
Model Q Variable Volume PUMPS



PRESSURE BOOSTERS



4-WAY VALVES



POWER UNITS

RACINE — STANDARD FOR QUALITY AND PRECISION — RACINE HYDRAULICS & MACHINERY, INC.

NFPA NATIONAL FLUID POWER ASSOCIATION Member

RACINE HYDRAULICS & MACHINERY, INC.
2073 Albert Street
RACINE, WISCONSIN

STEEL SHAPED TO CUT COSTS AND IMPROVE PRODUCTS

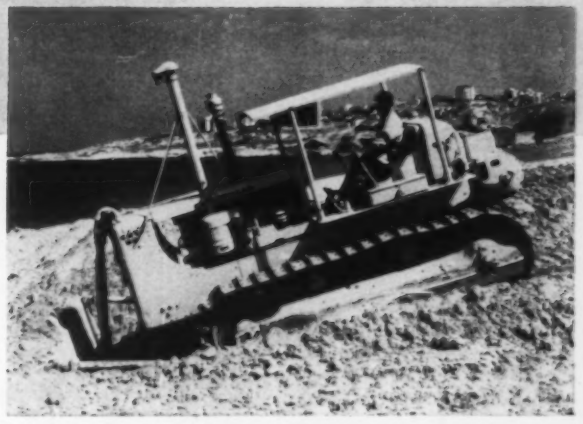
Caterpillar track shoe made from USS Special Section Rolled Steel Bars—a fast, low-cost method for making irregular parts.

Caterpillar makes this complex track shoe . . . from steel already rolled to shape!

The famous Caterpillar Crawler Tractors need a lot of shoes to make up their track—so the cost had to be kept low. To produce the highly irregular track shoe sections by machining, forging, casting or welding was either unsatisfactory, too costly or too slow.

They took the problem to U. S. Steel and a special section hot-rolled steel bar was suggested for the desired shape. The track shoes could then be sheared to the desired length. Three simple punching, shearing and drilling operations completed the job . . . and the shoes were ready for heat-treating and painting.

This method permitted more efficient production of track shoes, reduced the amount of steel needed, eliminated slow, costly machining, and cut scrap losses to rock bottom. The final shoe is strong, tough and long lasting.



Long life in rugged service has proved the quality of these shoes used in the endless track of Caterpillar Crawler Tractors.

Since 1928, Caterpillar track shoes have been produced by the thousands from USS Special Sections. No other production method has been devised that can compare with this for quality parts and low costs.

Why not get the facts on USS Special Sections? This is one way you can make substantial cost reductions and gain increased efficiency, too! United States Steel, 525 William Penn Place, Pittsburgh 30, Pennsylvania.

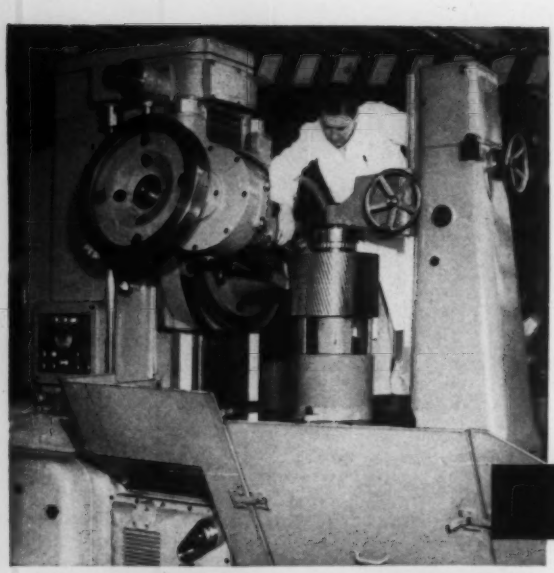
USS is a registered trademark

USS

United States Steel Corporation – Pittsburgh
Columbia-Geneva Steel – San Francisco
Tennessee Coal & Iron – Fairfield, Alabama
United States Steel Export Company

United States Steel

Please direct inquiries to advertiser, mentioning MACHINE DESIGN



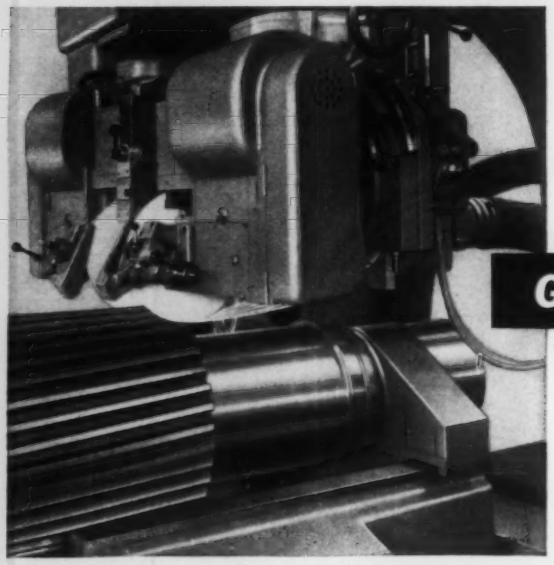
MOST MODERN MACHINERY ASSURES

ACCURACY

Phillie Gears are **made right,** then **carefully tested,** and finally **thoroughly inspected** . . . all of these operations are conducted by experienced craftsmen, using the very latest methods and equipment . . . in 4 modern plants.

Send for latest 76 page "Gear Book", G-127.

MADE ACCURATELY



GROUND ACCURATELY

CHECKED FOR ACCURACY

phillie gear®

PHILADELPHIA GEAR CORPORATION

ERIE AVE. & G STREET, PHILADELPHIA 34, PENNA.

Offices in all Principal Cities

Circle 427 on Page 19

here's how Crucible Fatigue-Resistant Springs are made stronger to last longer

Crucible *fatigue-resistant* springs outlast conventional heavy-duty coil springs many times. That's because they are shot peened.

Shot peening actually makes the springs stronger by imposing a compressive stress on the surface of the spring that offsets some of the working stresses set up in service. Further, shot peening conditions the surface. The high intensity peening eliminates stress concentration points that could lead to failure of a conventional spring.

Moreover, when you buy Crucible springs, you employ all of Crucible's many years of experience and metallurgical know-how in fine steelmaking – from ore to finished spring. Good springs demand the best in specialty steels. During manufacture, quality checks are made continuously. And a final magnetic test may be given if desired.

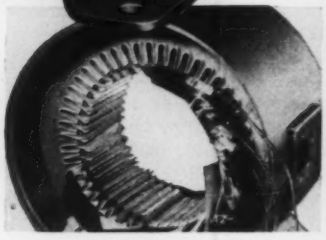
When you have a requirement for a spring that must endure rugged operating conditions, secure the built-in advantages of Crucible *fatigue-resistant* springs. And for technical assistance in designing or selecting heavy-duty springs, don't hesitate to consult with Crucible's spring specialists. For a free copy of a handbook on "Coil Spring Design," write to *Spring Division, Crucible Steel Company of America, McCandless Avenue, Pittsburgh 1, Pa.*

CRUCIBLE HEAVY-DUTY COIL SPRINGS

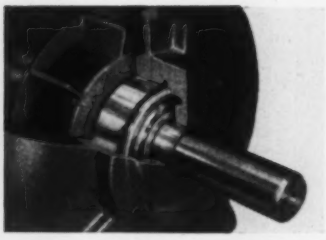
Circle 428 on Page 19

Udylite's

Robbins & Myers
build motors from
1/200 to 200 horsepower



MYLAR* INSULATION INCREASES MOTOR LIFE . . . insures positive insulation. Rag paper backing provides cushioning effect against abrasions and punctures. Entire motor winding is pre-heated, twice dipped in varnish and baked after each dip.



BEARINGS POSITIVELY SEALED . . . Double row width ball bearings, sealed on both sides, eliminate frequent re-lubrication. Grease sealed in extra-large reservoirs, resists dust, temperature, humidity and high operating speeds.

*DuPont registered trademark

"shining example" shows how...

R&M TOTALLY ENCLOSED FAN COOLED MOTORS BEAT CORROSIVE ATMOSPHERES

Udylite Corporation's famed Automatic Plating Machines put a shine on everything from sewing machine parts to automobile bumpers. R&M Totally Enclosed Fan Cooled Motors power the hydraulic system of these precision machines quietly, smoothly and without vibration. But most important they successfully combat the severe corrosive atmosphere common to all plating operations. R&M Motors are completely protected against this serious motor menace.

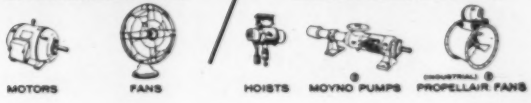
Complete R&M motor protection includes careful dipping, baking and painting of all steel parts . . . spraying of rotor and shaft with special rust-inhibitor . . . application of anti-corrosion primer to cast-iron end-heads and terminal box. A cast aluminum fan provides effective cooling by forcing air between enclosed internal and open external shells over motor's entire length. Other important features contributing to long-life protection and vigorous performance are described at left, below.

Robbins & Myers Totally Enclosed Motors range from ½ to 125 hp. Write today for Bulletin 500 MD

OPEN PROTECTED MOTORS . . . R&M open protected motors to 200 horsepower are suitable for many applications formerly requiring totally enclosed construction. Investigate this economical possibility for your application. Write for free Bulletin 520.

ROBBINS & MYERS, INC.

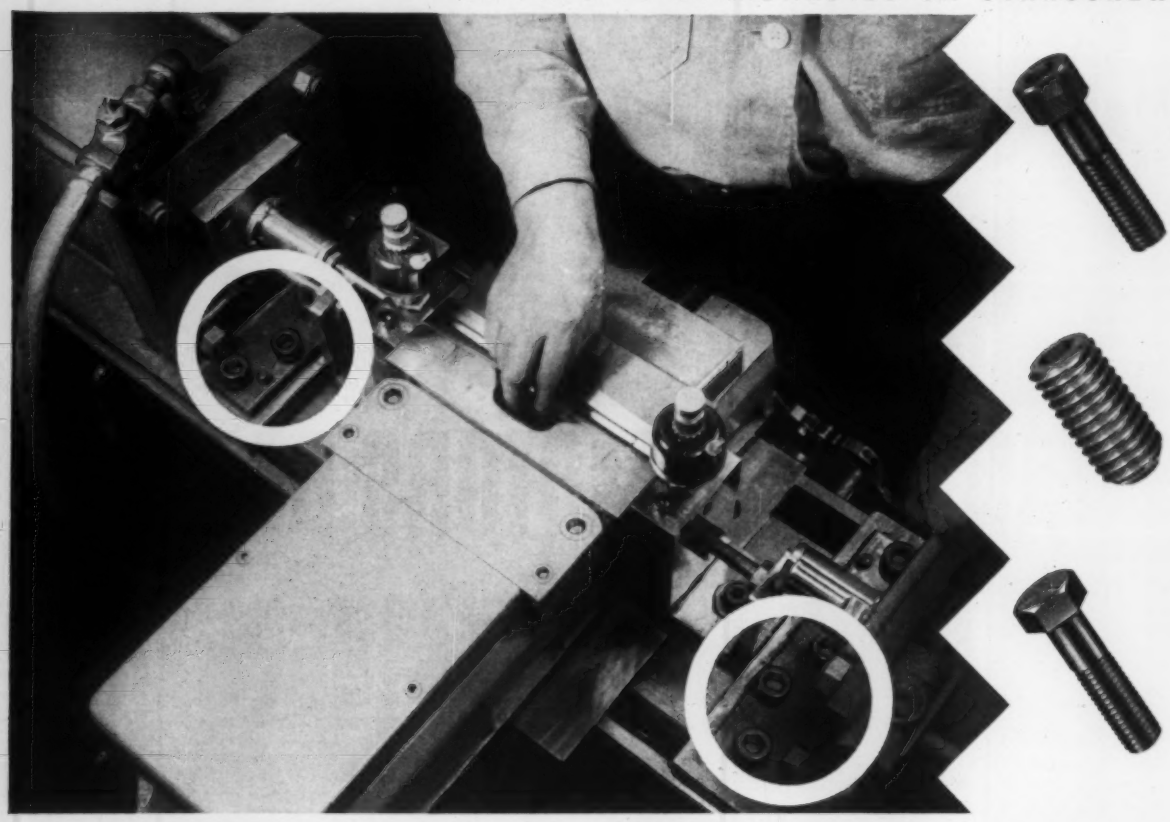
SPRINGFIELD, OHIO — BRANTFORD, ONTARIO



R&M

Circle 429 on Page 19

IT PAYS TO STANDARDIZE ON **STANSCREW**



A 20-ton impact load . . . 14,400 times a day! Stanscrew Fasteners solve the problem

Fastening the air cylinders on this tube former is a real problem. Each of these 8" bore cylinders delivers a thrust of over 20 tons every time the machine is operated. And since this happens 14,400 times in a normal working day, ordinary fasteners would soon fail under these repeated shock loads. Furthermore, not even the slightest misalignment can be tolerated in this machine.

The Stanscrew fastener specialist was able to quickly answer this demanding problem. His solution was Stanscrew Socket Head Cap Screws, tightened to within 80% of yield strength so they remained in tension. These fasteners, so applied, deliver a clamping force that eliminates the shock feature of this extremely high loading . . . and provides a 100% factor of safety.

Tough assignments like this are everyday jobs for your Stanscrew fastener specialist. Immediately on call, through your Stanscrew distributor, he can bring to your problem years of specialized experience. And, back of him, is an outstanding staff of engineers who have been solving the fastener problems of American industry since 1872.

Stanscrew's complete line of more than 4,000 different types and sizes will provide economical answers to your fastener requirements. All 4,000 items are always in stock, quickly available.

Call your Stanscrew distributor today for solutions to your fastener problems. He will arrange a prompt meeting with the Stanscrew fastener specialist . . . who can often suggest ways to save you money by substituting standard fasteners for costly specials.

STANSCREW FASTENERS

CHICAGO | THE CHICAGO SCREW COMPANY, BELLWOOD, ILLINOIS
HMS | HARTFORD MACHINE SCREW COMPANY, HARTFORD, CONNECTICUT
WESTERN | THE WESTERN AUTOMATIC MACHINE SCREW COMPANY, ELYRIA, OHIO

STANDARD SCREW COMPANY 2701 Washington Boulevard, Bellwood, Illinois

Circle 430 on Page 19

TO BRIGHTEN UP YOUR PRODUCT

Color helps sell these new Sunbeam electric fry pans and other Sunbeam Corporation appliances.

Where do you want to put the selling power of *color* to work in your product?

Now you can get rigid, strong parts like these *in a whole spectrum of opaque, light-fast colors.* How? With a new, amazingly durable plastic molding material—*Durez polyester.*

These parts combine rugged strength with other qualities you'll find in no other color plastic. Their electrical properties are outstanding. They're inherently fire-resistant—meet Underwriters' requirements for appliances.

You can use Durez polyester in many places where you can't use other plastics, because *molded parts show virtually no change in dimensions after molding!*

Your molder can get this new plastic now in a variety of standard colors. It comes in a dry granular form and is easily molded on standard presses with compression or transfer molds.

If you'd like to brighten up your product with strong, dimensionally stable parts like these, ask us for illustrated Bulletin 200. It shows how leading manufacturers are using Durez polyester to spur sales of consumer products. Write DUREZ PLASTICS DIVISION, Hooker Electrochemical Company, 506 Walck Road, North Tonawanda, New York.

Solves shrinkage problem! These parts for Singer Sewing Machine Co., molded from Durez polyesters, retain their shape better than any other color plastic. Parts fit together better for faster assembly, fewer rejects.

DUREZ® HOOKER CHEMICALS PLASTICS

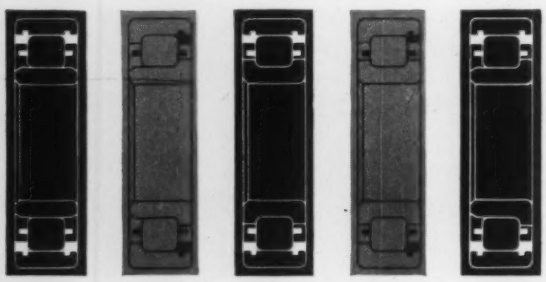
PLASTICS DIVISION

HOOKER ELECTROCHEMICAL COMPANY

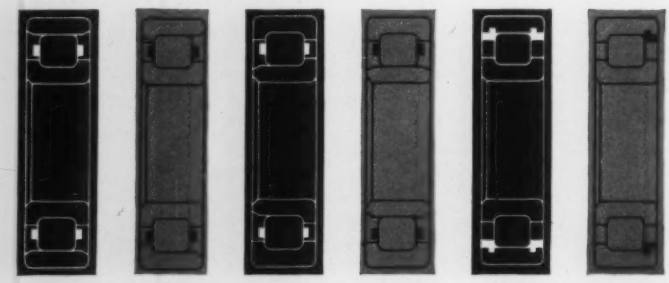
506 Walck Road, North Tonawanda, N. Y.

Circle 431 on Page 19

The Type UR-E Tru-Rol segmented-retainer bearing illustrated above, affords adequate precision, performance and life expectancy for most "upper range" commercial-grade applications.



E-B Separable Inner Race
L-J Separable Inner Race
U-B Non-separable Bearing
U-J Non-separable Bearing
L-B Separable Bearing



UR-E Separable Outer Race
UR-L Separable Outer Race
LR-U Separable Inner Race
E-U Separable Inner Race
UM-B Non-separable Full Roller
UM-J Non-separable Full Roller

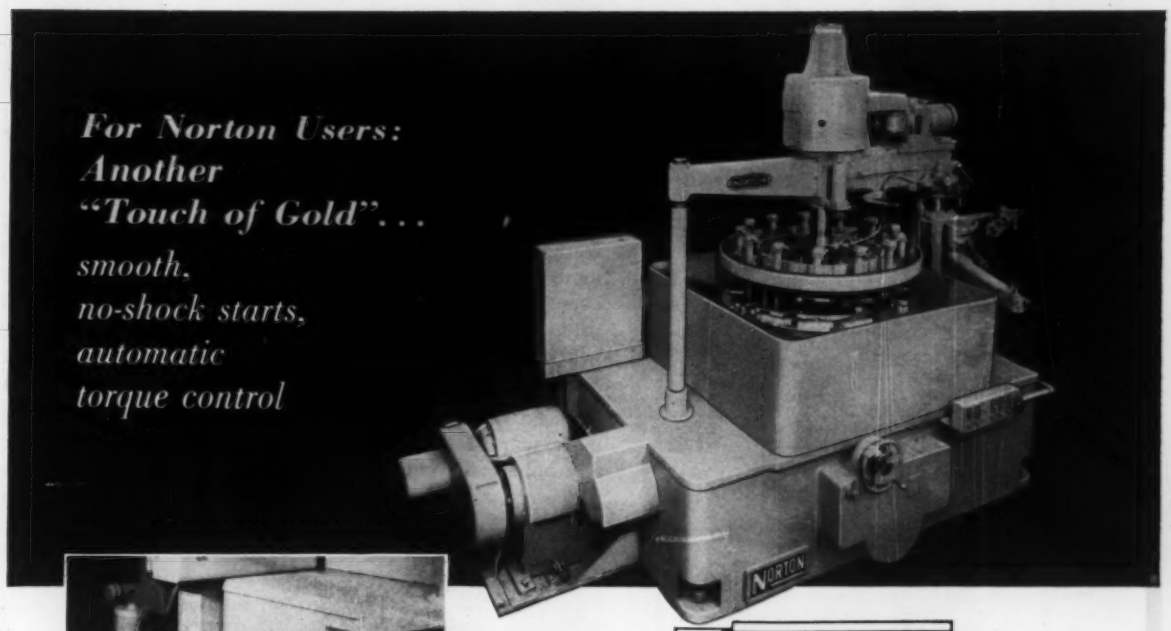
Rollway Tru-Rol Bearings give you "for the job" selectivity in a wide range of applications. They approach the design, precision and quality of bronze-retainer bearings as closely as commercial grade pricing will allow. Internal clearances are close. Rollers are equally spaced to avoid out-of-balance vibration and "pulse". And each is crowned to distribute the load evenly along the full length of the roller. 11 types available in single and double width bearings, in stamped steel retainer, segmented retainer or full roller construction.

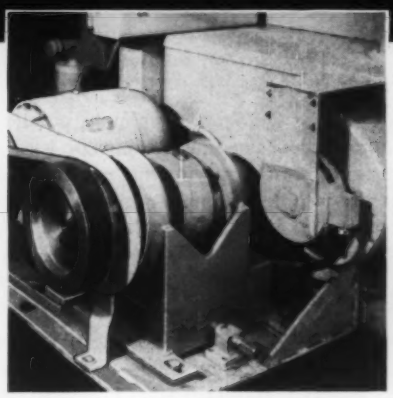
ask *a near-by Rollway Service Engineer to detail the quality you should be getting in your "commercial grade" bearings. No cost. No obligation. Write to*

ROLLWAY BEARING COMPANY, INC.
586 Seymour St., Syracuse, N.Y.
ENGINEERING OFFICES: Syracuse • Philadelphia
Boston • Chicago • Cleveland • Pittsburgh
Detroit • Seattle • Houston • Los Angeles
San Francisco • Toronto

Circle 432 on Page 19

For Norton Users:
Another
"Touch of Gold"...
smooth,
no-shock starts,
automatic
torque control





with the VICKERS®

MAGNECLUTCH®
magnetic particle clutch and
MAGNEBRAKE®

An important component of Norton Company's No. 48-F Hyprolap lapping machine shown above is the Vickers Magneclutch. This outstanding clutch provides the smooth, no-shock starts and the reliable automatic torque control needed for precise metal finishing. The Vickers Magnebrake used on the Hyprolap machine insures smooth, reliable braking. Magnebrakes can also provide shockless, controlled deceleration.

If critical torque transmission is needed in your equipment, you'll find many advantages in the Vickers Magneclutch . . . a magnetic particle clutch that provides smooth operation with no grab or chatter, fast response and long life (there's no wear on torque transmitting surfaces). Write today for Bulletin 6000-A.

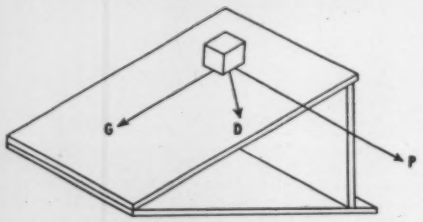
ELECTRIC PRODUCTS DIVISION — VICKERS

VICKERS INCORPORATED
DIVISION OF SPERRY RAND CORPORATION
ELECTRIC PRODUCTS DIVISION
1881 LOCUST STREET • SAINT LOUIS 3, MISSOURI

Circle 433 on Page 19

How FLEXLOC Self-Locking Nuts Help You Increase Product Reliability

WHY A NUT WORKS LOOSE



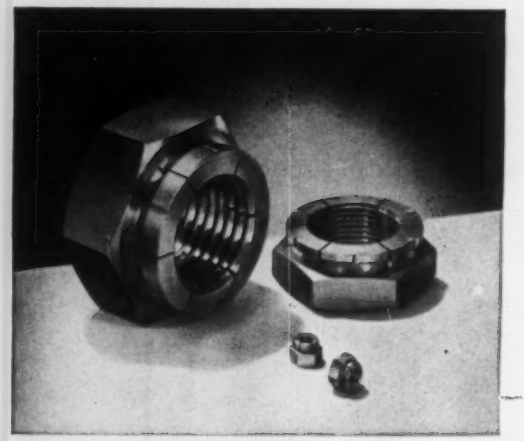
The reason why a nut works loose under vibration is best explained by the analogy of a free block on an inclined plane. Up to a certain angle of the plane, friction keeps the block from sliding (G). But if an external force starts to move the block sideways (P), friction can be reduced to the point where the block begins to slide down at the same time (D). A similar action occurs with screw threads. Tightening a nut forces its thread "uphill" against the thread of the screw or bolt. This sets up tension, creating enough friction between mating threads to hold the nut tight —under some conditions. Often, however, vibration causes marked variations in screw or bolt tension, resulting in motion between mating threads to the point where they begin to slip past one another or "run downhill." Result: creeping rotation of the nut and eventual loosening.

As products become more complex and more highly automated, mechanical failures become both more costly and more probable. As a result there is growing concern today over the problem of reliability, not only in the industrial field, but also among manufacturers of consumer goods, whose customers are increasingly irritated by the whopping annual repair bill on their automobiles and home appliances.

Faced with this demand for greater reliability, more and more manufacturers are adopting the rule of thumb that any bolted assembly subject to impact, shock or vibration will eventually loosen unless secured by a positive locking device. The trouble is that conventional locking devices are not always reliable. Lockwashers sometimes snap; jam nuts may work loose themselves; and cotter pins or wiring may permit partial loosening. Furthermore, these devices take extra time and labor to install.

FLEXLOC self-locking nuts offer you a simple, practical way to reliable, vibration-proof fastening. A FLEXLOC is a 1-piece, all-metal, self-locking unit requiring no auxiliary locking elements. There is nothing to put together, come apart, or get lost; there are no inserts to pop out or deteriorate. FLEXLOCs can be used as locknuts or stopnuts. They lock, seated or not, wherever wrenching stops. They will not vibrate loose, yet are easily removed and can be used repeatedly.

See your authorized SPS distributor for more information. He carries FLEXLOC self-locking nuts—regular and thin height—in a full range of standard sizes and materials. Or write Flexloc Locknut Division, STANDARD PRESSED STEEL Co., Jenkintown 18, Pa.



One-piece, self-locking FLEXLOCs require no auxiliary locking devices, no extra time or labor to install. Seated or not, they lock wherever wrenching stops . . . won't work loose.

hiRf High Reliability factor

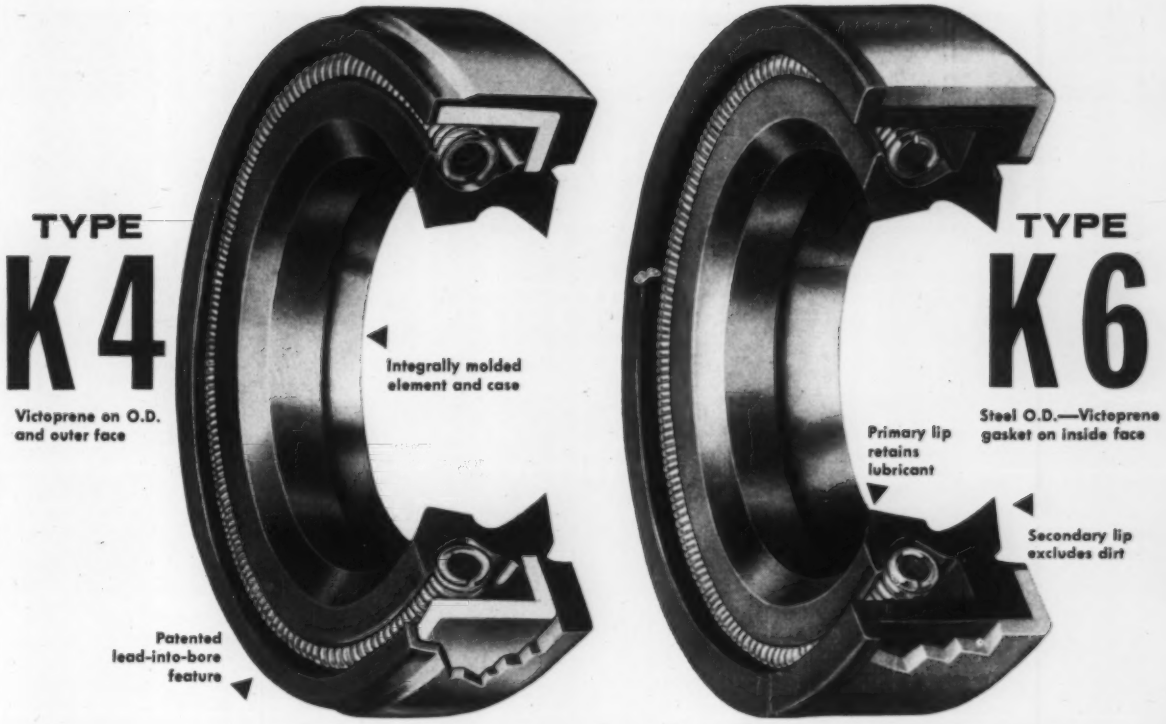
At SPS we apply a dynamic standard of quality—continually refined—so that our fasteners will always have the high reliability factor required by today's faster speeds, higher temperatures, and greater dynamic forces. By using SPS fasteners in your assemblies, you increase overall reliability—the certainty of predictable performance under actual service conditions.

Write for a copy of the current SPS booklet "Concerning High Reliability"—an introduction to the new science of reliability engineering.

We also manufacture precision titanium fasteners / write for free booklet

SPS **Jenkintown • Pennsylvania**

Standard Pressed Steel Co. • The Cleveland Cap Screw Co. • Columbia Steel Equipment Co. • National Machine Products Co. • Nutt-Shel Co. • SPS Western • Standco Canada Ltd. • Unbrako Socket Screw Co., Ltd.



Newest design for compact dual-lip sealing

Two types . . . as narrow as ¼ inch

In Type K4 Victoprene oil seal and its variant, Type K6, Victor offers a highly improved version of compound element shaft sealing. The two types accommodate varying installation and bore sealing needs, yet provide identical shaft sealing efficiency in the smallest housing space.

Check the design features. See how these seals can enhance your specifications for all types of machinery or automotive applications. You'll like their moderate price, too—and fast availability in all standard sizes! See your Victor Oil Seal Catalog No. 305.

DUAL SEALING SURFACES—Inner lip designed for maximum fluid retention. Outer lip excludes foreign matter or confines a secondary lubricant.

VICTOPRENE ELEMENT—Developed of improved Buna N synthetic rubber for balanced resistance to lubricants, heat, and age deterioration.

PRE-LUBRICATION CAVITY between lips provides for permanent lubrication on installation. Reduces frictional drag; extends seal life.

SPACE-SAVING NARROW WIDTH — Patented one-piece, integrally molded element and case construction permits most compact seal housing.

POSITIVE SPRING LOCATION—Molded groove in sealing element holds garter spring in proper place to keep uniform pressure on shaft.

POSITIVE BORE SEALING—*Type K4* has bonded-to-case Victoprene on O.D. and outer face. Patented lead-in feature aligns seal for easy installation. *Type K6*, for metal-to-metal installations, has steel O.D., with integral gasket on inside face for bottom of bore seal.

TYPICAL APPLICATIONS—Wheel bearing seals on automotive vehicles, farm and road machinery, etc.; crankshaft; pinion; automotive transmission (rear extension housings); speed reducers; winches, etc.

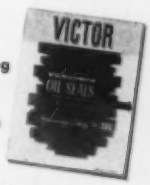
K4 and K6 seals supplied without spring where it is not required

Victor Mfg. & Gasket Co., P. O. Box 1333, Chicago 90, Ill.
Canadian Plant: St. Thomas, Ont.

VICTOR

Sealing Products Exclusively

Victor Oil Seal Engineering Catalog No. 305, sent free on request. No designer should be without it.



OIL SEALS • GASKETS • PACKINGS • MECHANICAL SEALS

No matter where your customers buy Macoma

Other Outstanding Shell Industrial Lubricants

Shell Tellus Oils—for closed hydraulic systems

Shell Alvania Grease—multi-purpose industrial grease

Shell Turbo Oils—for utility, industrial and marine turbines

Shell Rimula Oils—for heavy-duty diesel engines

Shell Talona R Oil 40—anti-wear crankcase oil for diesel locomotives

Shell Dromus Oils—soluble cutting oils for high-production metal working

Shell Voluta Oils—for high-speed quenching with maximum stability

Its performance and name are the same around the world

Shell Macoma Oils are premium quality, fortified extreme pressure gear oils. They provide superior high-load-carrying capacity and are particularly effective where overloading, severe shock-loading or general heavy-duty conditions exist.

Macoma* Oils have these added built-in benefits: excellent resistance to oxidation, great adhesiveness, rapid separation from water. They are non-corrosive, non-foaming and have high stability in storage.

The world-wide availability of Macoma Oils is assurance that your customers abroad will get the same performance from your equipment that your domestic customers rely upon. For complete specifications, write Shell Oil Company, 50 West 50th St., New York 20, N. Y. or 100 Bush St., San Francisco 6, California.

*Registered Trademark

SHELL MACOMA OIL

SHELL

CONTOUR TRENTWELD TUBING is available in a wide range of grades including Hastelloy,* Zirconium, Zircaloy, Titanium, 19-9-DL — and in 10 basic tubing classifications (pressure, mechanical, aircraft, heat resistant, ornamental, sanitary, beverage, large diameter, shaping and formed tubing).

*Trademark of Haynes Stellite Co

get high strength and uniformity with **TRENTWELD** stainless and high alloy pipe and tubing (*sizes range from 1/8" to 40" O. D.*)

As Trent makes them, today's welded pipe and tubing are as strong as — and even more uniform than — pipe and tubing made by any other method of manufacture. That's because (1) an exclusive welding process (Contour Trentweld®) virtually eliminates any bead or undercut, and (2) cold working and annealing after welding make the weld equal in strength and corrosion resistance to the parent metal.

Furthermore, Trent checks the quality of its pipe and tubing with a series of strict tests. All strip going into the welder is checked for width and tolerance. Samples of each lot are tensile tested. Periodic tests — flattening, reverse bend, flare and flange, coil and pressure — are conducted. Pipe and tubing for corrosive applications get rigid corrosion tests. And, if necessary, "single-wall" X-ray inspections, exclusive with Trent, can be made on any lot.

Naturally, pipe and tubing made to these standards can't be surpassed for strength, uniformity and service. But get complete details —

Mail coupon for free 48-page Trent tubing handbook — contains complete data on physical, chemical, electrical properties, corrosive data, theoretical weights, hardnesses, etc.

TRENT TUBE COMPANY
Subsidiary of Crucible Steel Company of America
General Offices, East Troy, Wisconsin

Gentlemen: Please send me the 48-page Trent Tubing Handbook.

*Name*_____

*Firm*_____

*Street*_____

*City*_____ *Zone*____ *State*_____

Circle 437 on Page 19

To combat chemical and solvent action . . .

Choose a J-M Teflon* Packing!

They're chemically inert . . . available immediately in the J-M Chempac® line

REPORTS from the field are the proof: you just can't beat J-M Teflon packings and gaskets for resistance to the constant attack of chemicals and solvents!

That's why we say . . . you'll find the answer to any corrosion problem in the J-M Chempac line . . . available in pure Teflon, or Teflon combined with asbestos. The latter construction offers the excellent sealing and heat resistance of asbestos, plus the added protection of Teflon against chemical and solvent action.

You'll find Chempac Teflon Packings in moulded and braided types for pumps and valves . . . in a wide range of flange and envelope-type gaskets . . . in rings, cups, sheets and tapes. Moreover, we can tailor-make packings, gaskets and precision-moulded parts to your exact specifications. Important, too, our new Teflon production facilities assure prompt delivery in any quantity you need.

Ask your Johns-Manville Packing Distributor to help you select the right Chempac Teflon Packing for your application—or write Johns-Manville, Box 14, New York 16, N. Y. In Canada, 565 Lakeshore Road East, Port Credit, Ontario. Ask for Brochure PK-124A.

*TM for Dupont Tetrafluorethylene resin

JOHNS-MANVILLE

why Yale & Towne powers with Chrysler Industrial Engines

CHRYSLER V-8 INDUSTRIAL ENGINE powers Yale G3P Lift Truck.

Lift trucks operate under a wide variety of rugged conditions. The Yale Model G3P, for example, usually works outdoors in all kinds of weather and, frequently, over rough terrain. The engine is exposed to rain, dust, dirt; extreme heat and cold. Demands upon the engine vary from short periods of full capacity lifting to long periods of idling. Yale & Towne has found that Chrysler engines meet these on-the-job requirements with power to spare. Most Yale customers are familiar with Chrysler power in other industrial applications. They respect the reputation of Chrysler Industrial Engines for economical and trouble-free performance. They know from first hand experience how Chrysler's nationwide service organization helps reduce down-time losses.

YALE & TOWNE EXECUTIVES

John A. Baldinger (left), Vice President, Yale Materials Handling Division; Thomas W. Curtin (right), Director of Purchases; Clyde R. Dean (seated), General Sales Manager. Yale Lift Trucks from 3,000 to 10,000 lb. capacity are powered by six-cylinder Chrysler Industrial Engines. Larger models (shown: Model G3P, 18,000 lb. capacity) are powered by Chrysler V-8 Industrial Engines with fluid coupling.

SEND for 1958 CHRYSLER INDUSTRIAL ENGINE CATALOG: Dept. 86, Industrial Engine Division, Chrysler Corporation, Detroit 31, Michigan.

Chrysler
INDUSTRIAL ENGINES
INDUSTRIAL ENGINE DIVISION • CHRYSLER CORPORATION

Circle 439 on Page 19

DESIGNING WITH ALUMINUM

NO. 28

This is one of a series of information sheets that discuss the properties of aluminum and its alloys with relation to design. Extra or missing copies of the series supplied on request. Address: Advertising Dept., Kaiser Aluminum & Chemical Sales, Inc., Department PD-1, 919 N. Michigan Ave., Chicago 11, Ill.

CLEANING AND PROTECTING ALUMINUM SURFACES

To aid designers in recommending maintenance procedures for aluminum finishes, this article summarizes the recommended uses and methods of applying mechanical, chemical, proprietary and wax-lacquer materials.

THE SUBJECT of cleaning and maintaining aluminum is a departure from the usual content of this design series. But with the growing importance of *product finish*, the designer today is as much concerned with lasting beauty as with development of a product itself.

Four Types of Maintenance

In general, the methods and materials for cleaning and protecting aluminum surfaces may be divided into four groups or types: mechanical cleaning, chemical cleaning, treatment with cleaner-wax-polishes, and waxing or lacquering. In most cases, only one of these types will be required to return the aluminum to its original pleasing luster. In some instances, a combination of them may be necessary. As a rule of thumb, the mildest treatment that produces satisfactory results should be used.

The natural oxide film which is responsible for corrosion resistance forms rapidly on clean aluminum exposed to air. This self-healing action assures the natural corrosion resistance of aluminum within a short time after cleaning. An *anodized* aluminum surface is virtually impervious to atmospheric influences. However, should it be desirable to clean anodized aluminum, washing with a warm solution of a mild soap is usually all that is necessary. In the event that an exceptionally tenacious soil is encountered, a mild abrasive cleaner should be used.

1. MECHANICAL CLEANING

The simplest, and therefore the most common, method for removing dirt from aluminum surfaces is mechanical cleaning. Because of their action, soaps and detergents are included as cleaning agents under this group. Actually, many soiled aluminum structures and vehicles can be cleaned with nothing more than soap and water applied with a soft scrubbing brush. Strong detergent solutions, if not thoroughly rinsed, may cause surface staining. Rinse thoroughly, wipe dry with a clean cloth.

Mild abrasive cleansers—such as the household cleansing and scouring powders—are effective in cleaning aluminum. Application is made with a cloth dampened in water. Surface must be rinsed well and wiped dry. *Caution:* always work with the grain of the metal.

Steel wool—for harsher abrasion—must be carefully used on aluminum, rubbing in the direction of the metal grain and using only enough pressure to remove the soil. Heavy pressure will mar the mirror reflectivity of the surface. Special care must be taken with "satin" finished aluminum to prevent polishing of the etched satin finish. Stainless steel wool, 00 size or finer, is preferable for cleaning aluminum because it will not cause corrosion if slivers become embedded. If steel wool soap pads are used, the aluminum surface must be thoroughly rinsed to prevent rust discoloration from embedded slivers.

When using abrasives, always bear in mind that they may alter the appearance of the aluminum finish. To minimize such change, always rub in the direction of the finished grain—never across the grain. Special care should be exercised in cleaning matte finished aluminum which has no grain.

2. CHEMICAL CLEANING

The fastest and least expensive way to clean aluminum surfaces, especially large areas, is to use liquid chemical cleaners. These cleaners may be obtained ready-for-use or in a concentrated form that requires dilution with water or mineral spirits before application. Because they can be applied rapidly by swabbing or spraying, they have found ready acceptance in the aircraft and railroad industries.

Solvent cleaners—kerosene, turpentine and naphtha—are especially good for greasy deposits and for heavy accumulation of grime. It is a good practice to rinse off the solution to avoid streaks or deposits. If a surface has been lacquered, it may be cleaned with a mineral solvent or turpentine and a soft

When using abrasive cleaners of any kind, care must be taken to work with the grain of the aluminum surface to avoid marring mirror or satin finish.

Either paint-spray equipment or clean brushes may be used to apply protective lacquers. Before lacquering, surface should be prepared by etching-type cleaner.

cloth. A clean absorbent material should be used for drying. Non-etching type chemical cleaners—available under brand names in ready-to-use and in concentrated form—are the fastest and least expensive way to clean large aluminum areas.

Etching chemical cleaners—phosphoric acid type (*not* to be used on anodized aluminum)—are heavy duty cleaners to be used when all other methods fail. Etching chemical cleaners change the appearance of the finish and may permanently harm the aluminum surface unless thoroughly rinsed, especially out of cracks, corners and holes. Care should be exercised to see that there is no run-down on the aluminum outside the area being cleaned.

If cleaning is followed by waxing, a non-etching type cleaner is usually preferred. However, etching type chemical cleaners (generally having a phosphoric acid base) are most effective for surfaces that are subsequently lacquered. The degree of etching can be controlled somewhat by the length of time that the cleaner is left on the aluminum surface. Manufacturers' directions should be followed carefully when using chemical cleaners. Chemicals left too long in contact with the aluminum surface may have a corrosive effect. Therefore, rinsing must be liberal and thorough.

Steam is an excellent mild treatment for removing dirt, grease deposits and common atmospheric soil. If cleaning additives are used, strong alkaline solutions are to be avoided. Following steam cleaning, surface should be rinsed thoroughly with clean water and dried with a clean cloth. Make sure there is no collection of moisture at the bottom edges of the aluminum.

3. CLEANER-WAX-POLISHES

Using any of the proprietary cleaner-wax-polishes which are available requires somewhat more time than either mechanical or chemical cleaning. However, despite the greater labor, they are not difficult to apply. Furthermore, they provide a limited amount of surface protection, and thus may eliminate the need for a waxing operation if cleaning is to be done on a frequent schedule.

Wax-base polish cleaners should be applied with a clean, soft cloth as directed by the manufacturer. The thin protective coating need not be removed unless the aluminum surface is to be lacquered. Because of the wax content, these products should be applied indoors or in shade. When working with large objects, a mechanical buffer is of great assistance. Because of the mildness of the abrasive, this type of cleaner is one of the safest for use on aluminum. Non-wax-base polish cleaners—such as used for cleaning glass—are satisfactory for cleaning aluminum, and abrasive waxes of the type used for cleaning metal tableware are effective in removing atmospheric grime deposits.

4. PROTECTIVE WAXES AND LACQUERS

Unless aluminum structures or vehicles can be cleaned at regular, frequent intervals, the metal surfaces should be protected against the discoloring effects of severe environments or travel grime. Waxing is the cheapest and simplest way to do this. Suitable waxes are available in either paste or liquid form. Generally, waxed aluminum surfaces can be cleaned by merely wiping them with a damp cloth. They may be rewaxed over previous wax coats that have been cleaned, but in time this built-up coating will yellow. When this happens, the wax should be removed with a solvent or a mild abrasive cleaner before further waxing.

A relatively permanent colorless protective coating on aluminum is given by one or two coats of clear methacrylate lacquer. This lacquer coating can best be applied with a spray gun. However, formulations for brush application are also available.

The best lacquering results are obtained by first cleaning the aluminum surface (except anodized surfaces which require no preparation) with an etching-type cleaner. A solution of one part cleaner to three parts water will provide a good "tooth" on the aluminum surface for better lacquer adhesion. Apply the solution over a small area that can be kept wet for three to five minutes. Before solution dries, flush surface with clean water—paying particular attention to cracks, grooves, corners and holes. Dry thoroughly. Swabbing with a half-and-half solution of denatured or wood alcohol and water will hasten drying.

Like all exterior surfaces, aluminum will collect air-borne dust and grime. Regular periodic cleaning will help preserve the appearance of any finish.

NOTE: Upon your request for reprints of this advertisement, we will also send you a brochure containing a list of materials suitable for cleaning and protecting aluminum. (These materials have been evaluated by Kaiser Aluminum's Department of Metallurgical Research, but inclusion in the list does not constitute an endorsement or preference over similar materials intended for the same purpose.)

And for further information and assistance concerning specific problems in cleaning and protecting aluminum surfaces, contact the Kaiser Aluminum sales office or distributor listed in your telephone directory. Kaiser Aluminum & Chemical Sales, Inc., *General Sales Office*, Palmolive Bldg., Chicago 11, Ill.

see our catalog in
PRODUCT DESIGN FILE
or write for copy

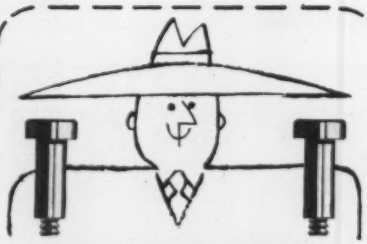
KAISER ALUMINUM
THE BRIGHT STAR OF METALS

SEE "MAVERICK" • SUNDAY EVENINGS, ABC-TV NETWORK • CONSULT LOCAL TV LISTING

CAP SCREWS

keep your cap on tight.

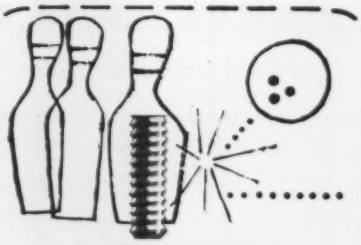
Owners of Thunderbirds, Corvettes and other snazzy top-down convertibles, tell us our special alloy and stainless steel P-K SOCKET HEAD CAP SCREWS do a mighty fine job of keeping their caps on. Naturally they specify PARKER-KALON, because they know P-Ks are instrument tested and inspected at every step of manufacture.



SHOULDER SCREWS

keep shoulders from sagging.

Used on either shoulder, or preferably both, P-K SHOULDER SCREWS will make you stand straighter, look better, may even result in getting you a substantial raise. Dependable, too. Heads are concentric with body for uniform, accurate assembly. Finished threads are close to shoulder for maximum holding power. And P-K SHOULDER SCREWS are accurate for positive internal wrenching and non-slip drive.



SET SCREWS

help make your score look good.

When the pin boy sets the pins for your opponent, he inserts a P-K SOCKET SET SCREW. Nobody'll know what's happening. Even a perfectly placed ball won't budge the pins as those P-K Set Screws hold them firmly to the floor. Same fine job in your plant, too. Use a P-K Cup Point for collars on pulleys and shafts, P-K Flat Point against hardened steel, and there's a selection of P-K Oval, Cone and Half-Dog Points from which to choose.

BUTTON HEADS

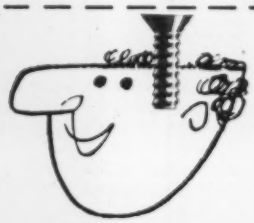
for you know who . . .

Take that neighbor who borrows your tools and never returns them. You can't openly call him names—his wife and yours are PTA buddies. So, just place a few Button Heads around his doorstep. He'll get the idea. And don't forget, you can also use P-K BUTTON HEAD CAP SCREWS for attaching cover plates and guards to production equipment and machine tools where countersinking isn't practical.

guide to

P-K

SOCKET SCREWS



FLAT HEADS

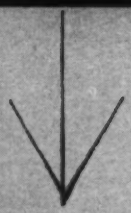
for that well-groomed look.

Holes in the head are apt to cause talk. Especially where the top of the noggin tends to be flat and somewhat bald. Users can remove hats without embarrassment. P-K FLAT HEAD SOCKET CAP SCREWS are flush when countersunk, leaving smooth surfaces unmarred by burred slots. Use for fastening thin strips, moldings, plates and sheet metal where maximum head contact is required.

HEX KEYS

for putting a hex on people.

Persons planning the quiet disappearance of friends or neighbors, or merely interested in more productive shop practices, should always remember to specify P-K ENGINEERED HEX KEYS. They're heat treated under laboratory supervision to assure maximum resistance to torque stresses and freedom from brittleness. And come in handy for tightening those mighty fine socket screws offered by Parker-Kalon.



Like a copy of this guide for your office? We'll be glad to send a reprint suitable for framing.

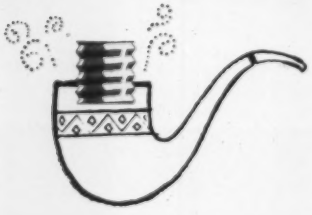
PARKER-KALON®

SOCKET SCREWS

Sold only through industrial supply distributors

PARKER-KALON DIVISION, General American Transportation Corporation, Clifton, N. J.

Originators of the Self-tapping Screw; Manufacturers of Screw Nails, Masonry Nails, Wing Nuts, Thumb Screws and the new Rimguard Weld Screws.



PIPE PLUGS

. . . just dandy for that old pipe.

P-K SOCKET PIPE PLUGS are the perfect answer whenever smoke gets kinda thick in the house and the little woman starts to get that look on her face. Drive one firmly into the bowl of your favorite pipe. No smoke escapes and all is peaceful. Examine a P-K Pipe Plug. Controlled chamfer makes for fast starting of threads. And P-Ks *Dryseal* produces a positive sealing without the necessity of a compound.

the ultimate in air cylinder power-

BUILT-IN ELECTRICALLY-CONTROLLED DIRECTIONAL VALVE

BUILT-IN DUAL SPEED CONTROLS

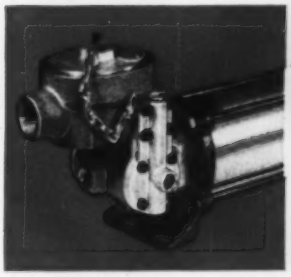
REQUIRES ONLY A SINGLE AIR CONNECTION

THE BELLOWS AIR MOTOR

The Bellows Air Motor is a complete air cylinder power unit, with directional valve and speed controls built-in. Takes less than half the space and costs less installed than a conventional air cylinder set-up of equal power with its separate valving and piping. The single air connection, which can be made with flexible hose, makes it ideal for use on moving machine elements. It is a sturdy unit with forged steel heads, heavy brass cylinder, stainless steel piston rod. The piston rod is threaded, equipped with a wrench flat and nut. Many Bellows Air Motors have been operating day in and day out for fifteen years with negligible maintenance. And if service needs do arise, there is a Bellows Field engineer as near as your phone.

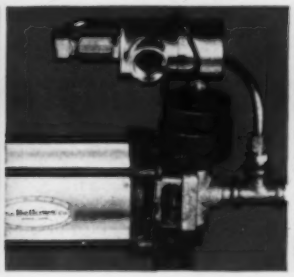
The Bellows Air Motor shown above is a 2½" bore unit equipped with the Bellows Low-Voltage (8-12V) Electroaire Valve. Other bores available are 1¼", 1¾", 3⅜" and 4½". Any stroke length. Optional choice of built-in valves as shown below.

CHOICE OF BUILT-IN VALVES

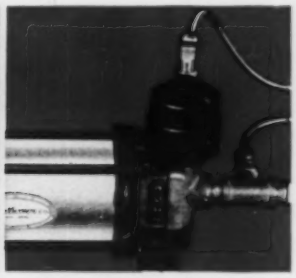


115 V. ELECTROAIRE VALVE
For J.I.C. applications where a 115 v. momentary contact is desirable.

MECHANICAL VALVE
For manual operation or for use with cams or direct linkage.



115 V. MAINTAINED CONTACT
Valve remains in shifted position during period current is applied.



AIR-OPERATED
For use in applications calling for full pneumatic control.

Write for these two booklets

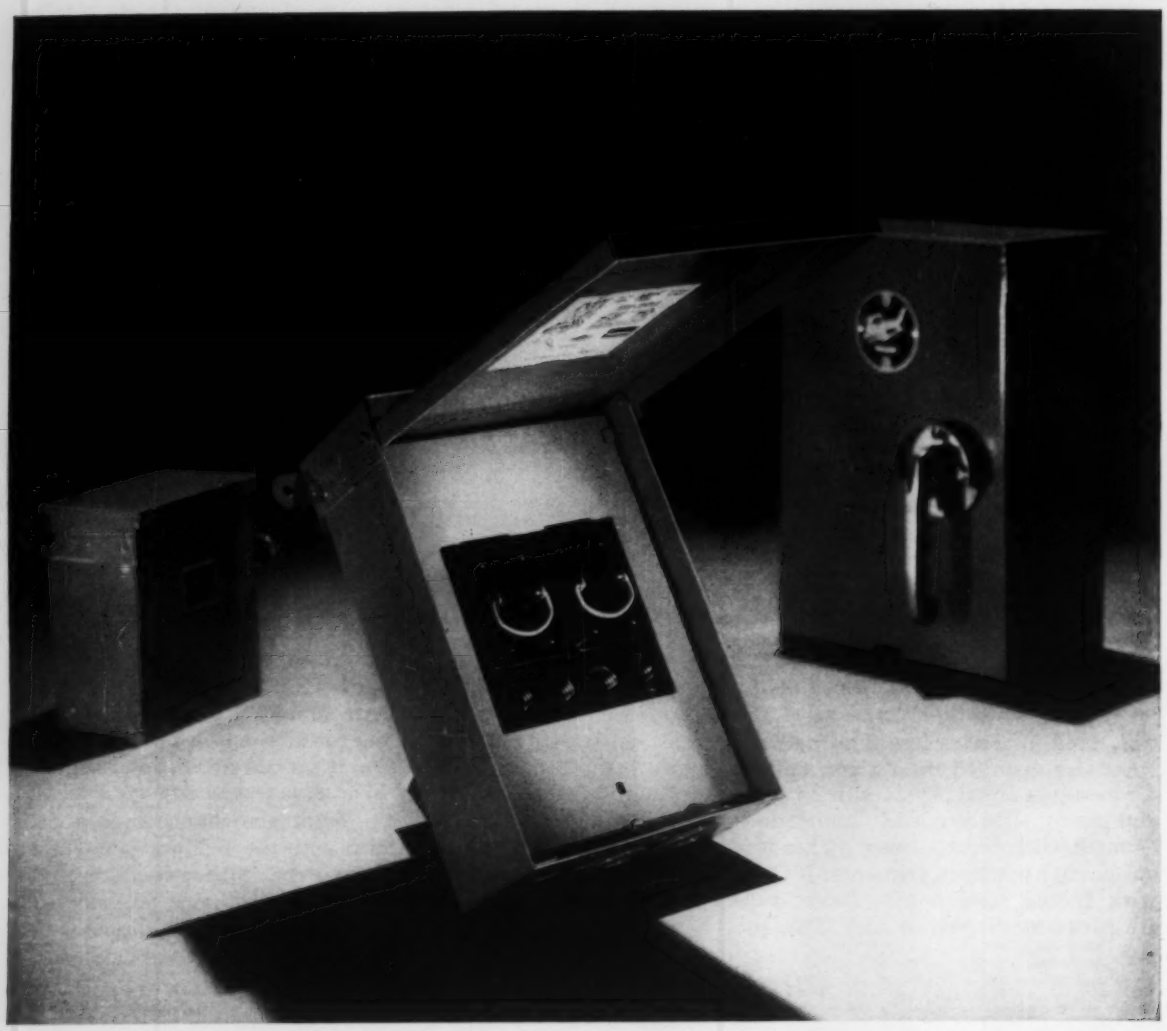
Fifty pages of data to help you select the right Air Motor-Valve combination for your job. Address Dept. MD-658, The Bellows Co., Akron 9, Ohio. In Canada: Bellows Pneumatic Devices of Canada, Ltd., Toronto 18. Ask for Bulletins BM-25 and SP-55.

The Bellows Co.

DIVISION INTERNATIONAL BASIC ECONOMY CORPORATION

AKRON 9, OHIO

983-B



Bethcon sheets improve raintight enclosure

Selecting the right material for the enclosure of an outdoor electric switch involves several important factors, according to engineers of Federal Pacific Electric Company, Newark, N. J. Among these are formability, corrosion-resistance, and low cost.

Federal found that Bethcon galvanized steel sheet best answered their requirements for raintight switch enclosures. "Formability without flaking is the thing," sums up a Federal production official. "These enclosures have to be formed under fairly severe conditions, and we can't have any cracking or peeling of the zinc where corrosion could get a toehold. Bethcon is the only material we've found that will give us the results we want, and meet our other requirements." That calls for truly superior galvanizing.

The reason for Bethcon's superior zinc coating is the fact that Bethcon is galvanized by Bethlehem's continuous process. Years of research have shown that this process produces a tighter, more uniform coating that won't crack even when the sheet is doubled back on itself. Spangles are brighter, too.

Where you need the strength of steel, coated for corrosion-resistance, you're likely to find Bethcon a new answer to your problem. Why not discuss its possibilities with a Bethlehem representative? Just call us for a date.

BETHLEHEM STEEL COMPANY, BETHLEHEM, PA.

On the Pacific Coast Bethlehem products are sold by
Bethlehem Pacific Coast Steel Corporation
Export Distributor: Bethlehem Steel Export Corporation

BETHLEHEM STEEL

BETHLEHEM STEEL

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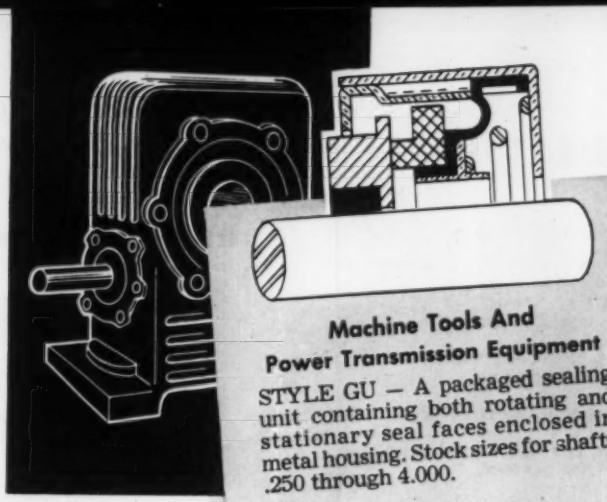
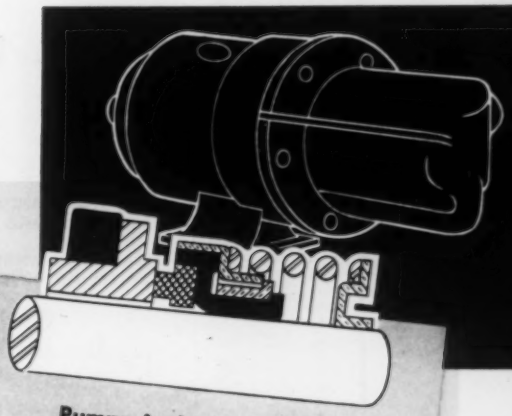


Machine Tools And Power Transmission Equipment

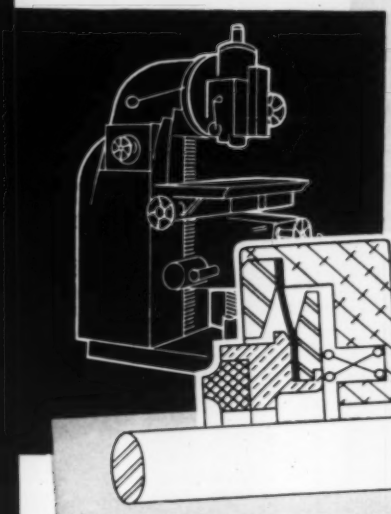
STYLE GU — A packaged sealing unit containing both rotating and stationary seal faces enclosed in metal housing. Stock sizes for shafts .250 through 4.000.



Pumps And Compressors

ROTO-FLEX — Rugged flexibility. Only 3 parts. Single or double units. Stock sizes for shafts .250 through 4.000.

STYLE RFO — A specially designed Roto-flex seal, for installation outside the stuffing box. Stock sizes for shafts .250 through 4.000.



Heavy Machine Tools

STYLE DPC — A high-speed, carbon-faced seal, for more compact installation in heavy industrial machinery. Stock sizes for shafts .250 through 4.000.

A Complete Line

GITS SHAFT SEALS

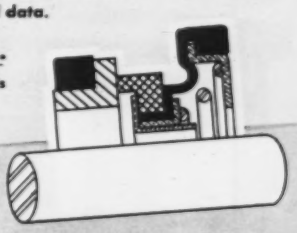
For Every Application

These modern, mechanical, face-type seals are carried in stock — to save you time and money. Write for detailed data.

GITS BROS. MFG. CO.

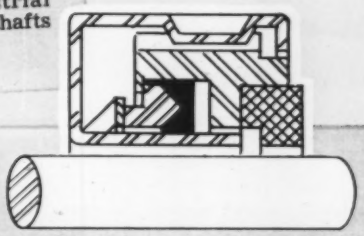
1868-A South Kilbourn Avenue • Chicago 23, Illinois

Specialists In Lubricating Devices And Shaft Seals For Almost Half-A-Century



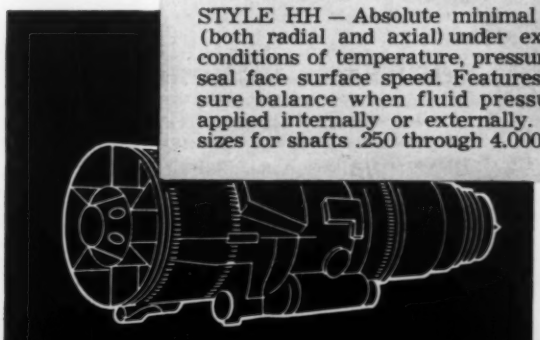
Household Appliances

STYLE SGU—A factory-assembled unit-type seal for the small-budget user. Stock sizes for shafts .250 through 1.000.



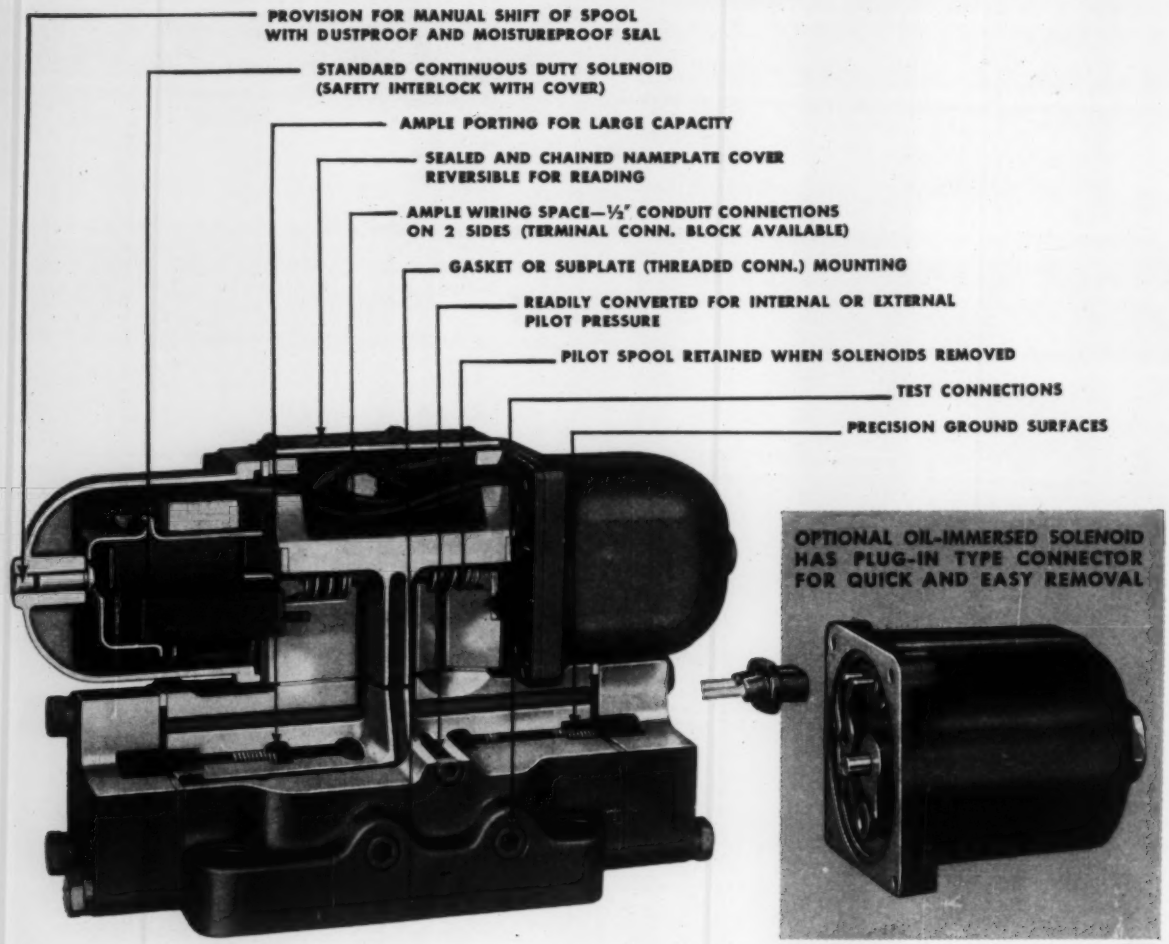
Aircraft Engines And Accessories

STYLE HH — Absolute minimal space (both radial and axial) under extreme conditions of temperature, pressure and seal face surface speed. Features pressure balance when fluid pressure is applied internally or externally. Stock sizes for shafts .250 through 4.000.



Circle 444 on Page 19

Only VICKERS® DIRECTIONAL VALVES Have *All* These Features


PROVISION FOR MANUAL SHIFT OF SPOOL WITH DUSTPROOF AND MOISTUREPROOF SEAL
STANDARD CONTINUOUS DUTY SOLENOID (SAFETY INTERLOCK WITH COVER)
AMPLE PORTING FOR LARGE CAPACITY
SEALED AND CHAINED NAMEPLATE COVER REVERSIBLE FOR READING
AMPLE WIRING SPACE—½" CONDUIT CONNECTIONS ON 2 SIDES (TERMINAL CONN. BLOCK AVAILABLE)
GASKET OR SUBPLATE (THREADED CONN.) MOUNTING
READILY CONVERTED FOR INTERNAL OR EXTERNAL PILOT PRESSURE
PILOT SPOOL RETAINED WHEN SOLENOIDS REMOVED
TEST CONNECTIONS
PRECISION GROUND SURFACES
OPTIONAL OIL-IMMERSED SOLENOID HAS PLUG-IN TYPE CONNECTOR FOR QUICK AND EASY REMOVAL
7897

REDUCED DOWN-TIME
LONGER SOLENOID LIFE
LESS MAINTENANCE
EASIER INSTALLATION

Vickers hydraulic 2- and 4-way valves provide the optimum in directional control. They are compact, versatile, and are designed for heavy duty, continuous and rapid cycling operation on all types of industrial machinery. More than a decade of application experience and years of research and development back all the valves' features.

Seven spool types satisfy a wide variety of circuit needs and operate at pressures to 3000 psi. Optional oil-immersed solenoids operate cooler, increasing service life 20 to 30 times.

Installation is simplified with ease of wiring and a minimum of piping. The valves are available for gasket or sub-plate mounting. Mounting position is unrestricted except in "no-spring" models. The optional oil-immersed solenoid has a plug-in type connector and is available in all standard voltages. Field modification of existing units can be made to incorporate heavy-duty, oil-immersed solenoids.

The valves conform to JIC Standards and are available in ⅛" and ¼" direct solenoid operated models . . . ¾", 1¼", 2", and 3" solenoid controlled pilot operated models. These valves cover the flow range from 1.25 gpm to 320 gpm.

For further information, write for Installation Drawing I-182412.

VICKERS INCORPORATED
DIVISION OF SPERRY RAND CORPORATION
Machinery Hydraulics Division
ADMINISTRATIVE and ENGINEERING CENTER
Department 1430 • Detroit 32, Michigan

Application Engineering Offices: ATLANTA • CHICAGO • CINCINNATI CLEVELAND • DETROIT • GRAND RAPIDS • HOUSTON • LOS ANGELES AREA (El Segundo) • MINNEAPOLIS • NEW YORK AREA (Springfield, N.J.) • PHILADELPHIA AREA (Media) • PITTSBURGH AREA (Mt. Lebanon) • PORTLAND, ORE. • ROCHESTER ROCKFORD • SAN FRANCISCO AREA (Berkeley) • SEATTLE • ST. LOUIS • TULSA WORCESTER

FACTORIES ALSO IN AUSTRALIA, ENGLAND, GERMANY AND JAPAN
IN CANADA: Vickers-Sperry of Canada, Ltd., Toronto, Montreal and Vancouver

BOMBS AWAY...

with the help of heat-treated TITANIUM ALLOY

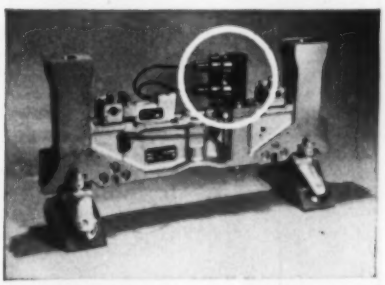
On high speed military planes, such as the Douglas A3D-2 Skywarrior and other jet aircraft, the bomb ejector rack is a complicated and critical mechanism. Any failure might endanger both airplane and pilot.

Three basic parts make up the ejector . . . cylinder, piston and breech. The latter presented the greatest design problem, due to its multitude of functions and irregular shape. Similar breeches made from stainless steel frequently heat-checked and failed, during test firing or hydrostatic testing.

Experience and design calculations suggested that 6Al-4V titanium alloy, produced by Mallory-Sharon, was the metal most likely to meet the exacting requirements.

Actual firing tests confirmed the advantages of titanium for this application. The titanium alloy breech withstood 300 firings before any evidence of heat checking appeared. No failures occurred in firing . . . and the breech withstood hydrostatic pressure of 27,000 psi without failure.

Here's one more example of titanium's outstanding performance in meeting critical design problems. May we help you explore its advantages for *your* product or application? Write for "Titanium Fact File".



Above: Bomb ejector rack, showing forged titanium alloy breech (circled).

Below: Titanium alloy ejector breech, before and after machining.

WHY TITANIUM WAS CHOSEN

1. High strength-to-weight ratio at elevated temperatures for short times.
2. Superior corrosion and erosion resistance.
3. Excellent forgeability.
4. Good machineability in the heat-treated condition.
5. Low susceptibility to hydrogen embrittlement.
6. Good thermal stability.

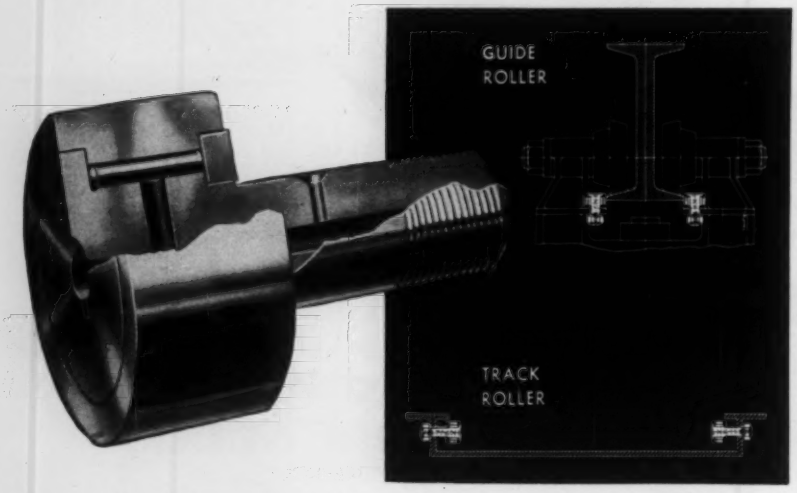
MALLORY SHARON

MALLORY-SHARON METALS CORPORATION • NILES, OHIO

Integrated producer of Titanium • Zirconium • Special Metals

BEARING TIPS by McGill

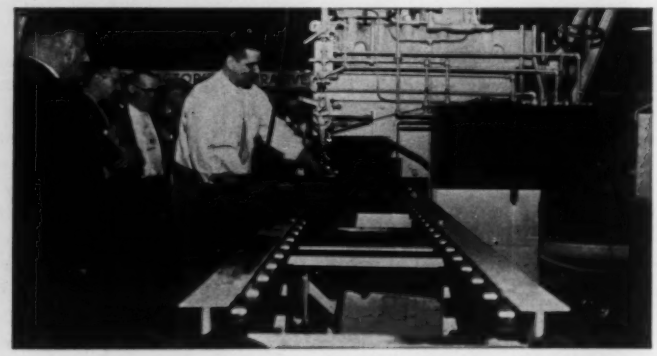
Let a CAMROL® bearing be your guide



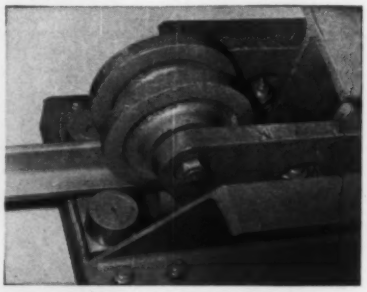
Obtain freer rolling, improved alignment and positive side thrust

In guide and support roller applications CAMROL Cam Followers insure free rolling action and positive side thrust while eliminating the wear of more costly flanged wheels. Then, too, they provide improved alignment and low starting and running friction with high unit load and shock capacity, especially at low speeds as track rollers. Lubrication is simplified and maintenance can be reduced to a minimum in these applications. Specify the interchangeable sealed SGR series for added protection against contamination.

CAMROL® CF bearings provide friction-free track rollers for automatic mold blower



McGill CAMROL CF rollers are used as guide rollers to form a mold conveyor in the Beardsley & Piper MBS-20 Mold Blower. The machine blows and squeezes cope or drag in a single automatic operation, handling up to 4 molds per minute. The CAMROL CF bearings replaced less efficient friction rollers in this application. Although, the duty here is rather light and speeds slow, the cam follower bearing provides lesser starting and running friction. This helps speed the flow of work from the machine, which must be fast and automatic. The integral stud feature eases assembly and its standard design simplifies procurement.



CF bearings minimize maintenance as crane side guide rollers

McGill CF cam follower bearings serve as side guide rollers in overhead cranes manufactured by Louden Machinery Company of Fairfield, Iowa. Freedom from maintenance, a time saver because of the inaccessibility of the bearing when the crane is in operation, is an important advantage of the cam follower bearing.

Send for Catalog No. 52-A

Insure performance with McGILL®

MULTIROL® GUIDEROL® CAMROL
Precision Needle Bearings

McGILL MANUFACTURING COMPANY, INC., 200 N. LAFAYETTE ST., VALPARAISO, INDIANA

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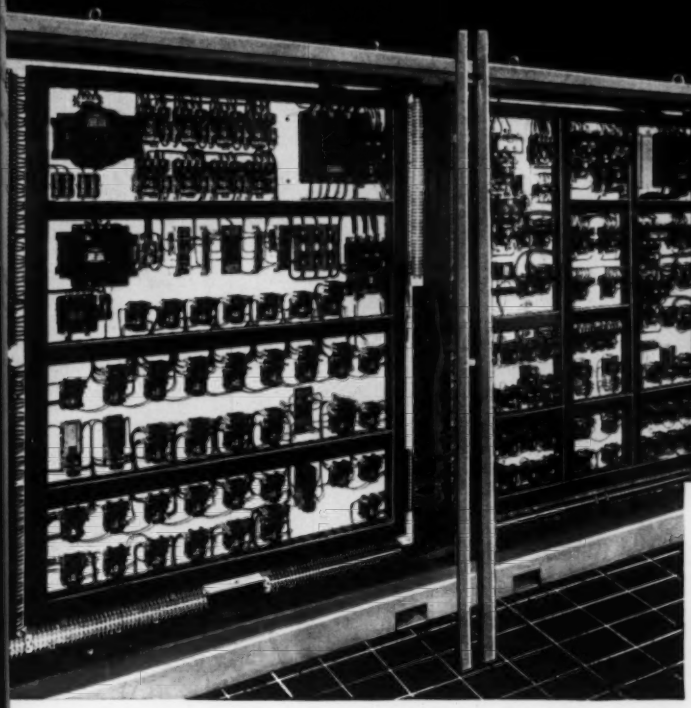
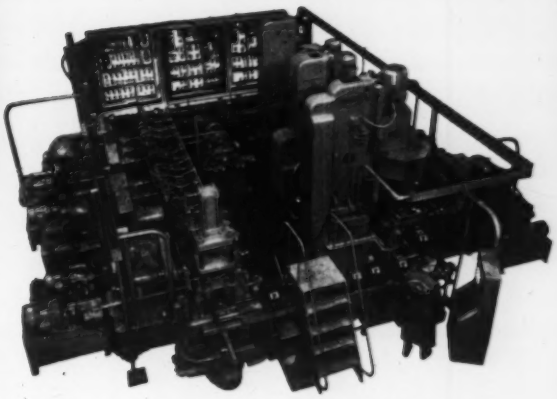
Circle 448 on Page 19→



preferred . . .
because it is

reliable!



This Baker Automatic Transfer Machine is equipped with a special Allen-Bradley control panel, assembled from standard components listed in the latest A-B Handy Catalog.

ALLEN-BRADLEY
MOTOR CONTROL
QUALITY

Twenty-six machining operations are performed automatically on this huge transfer machine. To keep this machine operating continuously—to avoid costly production shutdowns—Baker Brothers, Inc., selected Allen-Bradley quality motor control—the simple control that is good for millions of trouble free operations.

The recognized reliability of Allen-Bradley motor starters and relays is the result of their simple design. Having only *one* moving part, wear and consequent trouble are reduced to the minimum. The double break, silver alloy contacts . . . standard throughout the Allen-Bradley line . . . never need attention. They are always in perfect operating condition.

Simplicity of design and silver alloy contacts are features of all Allen-Bradley control auxiliaries—they are similarly trouble free. Therefore, standardize on the Allen-Bradley line of *quality* motor starters, relays, push buttons, limit switches, and other accessories. You cannot possibly make a mistake!

Allen-Bradley Co., 1316 S. Second St., Milwaukee 4, Wis.
In Canada: Allen-Bradley Canada Ltd., Galt, Ont.

BULLETIN 802T
Oiltight
Limit Switch

Has completely sealed operating head and switch body. This adjustable roller lever type saves installation time.

BULLETIN 700
Solenoid Relay

Universal type relay has contacts that can be connected for either "normally open" or "normally closed" operation.

BULLETIN 709
Solenoid
Starter
(Size 1)

Popular across-the-line starter with accurate and reliable overload relays. 8 Sizes to 300 hp, 220 v; 600 hp, 440-550 v.

7-58-R

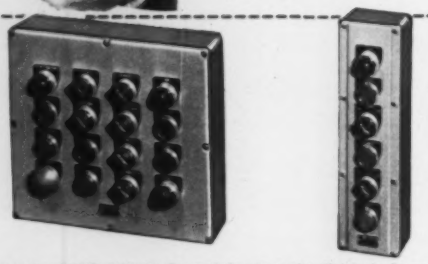
A-B
QUALITY

Not only the Motor Starters, but the Accessories must be "Quality," too!

A-B QUALITY

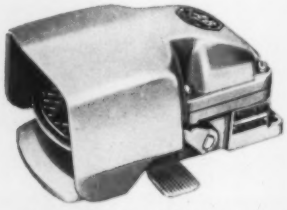
we specify ALLEN-BRADLEY ...all the way

"Trouble" that shows up in a motor starter is often traced to a faulty operating auxiliary—such as a limit switch or even a push button station. Allen-Bradley builds the same high quality into its many accessories as it does into its motor starters—to give you millions of trouble free operations. They are also tested as thoroughly. Contacts are usually double break and always are of a silver alloy, which means they remain in perfect operating condition. It will pay you, too, to specify Allen-Bradley *Quality* control—"all the way!"

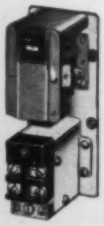


Bulletin 800T Oiltight Control Stations. Available in from one to sixteen units, in die cast aluminum enclosures.

Bulletin 802 Precision Limit Switch, with oil-tight head and body.

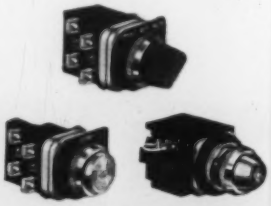


Bulletin 805 Foot Switch. In rugged die cast enclosure for the toughest service.



Bulletin 849 Pneumatic Timer. Reliable and accurate.

Bulletin 837 Temperature Control with snap action, precision switch.



Bulletin 800T Oiltight Push Button, Selector Switch, and Press-to-Test Pilot Light.

Bulletin 800 Standard Duty Push Button. One, two, and three buttons; also as selector switch.

Bulletin 836 Pressure Control in NEMA 4 watertight enclosure.

7-58-R

Allen-Bradley Co.
1316 S. Second St., Milwaukee 4, Wis.
In Canada: Allen-Bradley Canada Ltd., Galt, Ont.

ALLEN-BRADLEY
QUALITY
MOTOR CONTROL

Hot Extruded, Cold Drawn Steel Shape

"REDUCES PAWL PRODUCTION COSTS 75%"

...reports Snow Manufacturing Company

Production costs were cut 75% when the Snow Manufacturing Company converted to this J&L hot extruded, cold drawn shape as a pawl on a dial indexing fixture.

The pawl was formerly machined from a hot rolled flat section. Only operation now required is cutting from the extruded section and drilling a hole.

J&L's unique hot extruded, cold drawn sections can cut your production costs by reducing machining operations. Scrap losses are small. Mechanical properties are uniform throughout the bars, which can be produced with extremely close tolerances.

The range of sections that can be produced is almost unlimited. Let J&L show you how you can utilize this cost-cutting process.

Call your J&L district office or write direct to Jones & Laughlin, Department 410, 3 Gateway Center, Pittsburgh 30, Pa.

J&L STEEL

Jones & Laughlin Steel Corporation

PITTSBURGH, PENNSYLVANIA

Circle 449 on Page 19

NEW FROM Saginaw

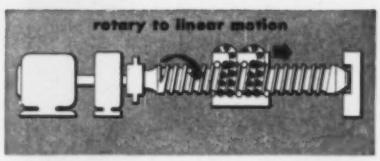
PHOTOGRAPHED ACTUAL SIZE
BALL CIRCLE DIAMETER: only 3/16 inch

SMALLEST ball/bearing SCREW OFFERS BIGGEST ANSWER TO CRITICAL POSITIONING/CONTROL PROBLEMS

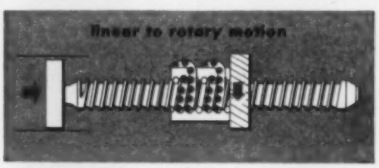
Another timely development by Saginaw . . . for imaginative manufacturers of ultra-precise controls in the electrical and electronic fields. For Saginaw Miniature b/b Screws will solve critical positioning/control problems for radar tuners, missile and rocket guidance and telemetering systems, automatic switch-gears, electronic machinery controls . . . plus a host of other applications.

These amazing little fellows are so compact and weigh so little—you can save greatly on space and weight. So efficient—over 90%—you can use much smaller motors and gear boxes. So precise—you can position components within .0005 inch per inch of travel. (If application requires, lash can be eliminated.) So dependable—you can rely on remarkably long service life even in extremely adverse environments.

Every day Saginaw's experienced engineers are helping more and more forward-looking manufacturers to gain these advantages of Saginaw Miniature b/b Screws. Let them help you plan your application. No obligation. Simply phone, write or mail the convenient coupon below.



NUT TRAVELS: When rotary motion is applied to the screw, the b/b nut glides along the axis of the screw on rolling steel balls, converting rotary force and motion to linear force and motion with 4/5 less torque than acme screws.



SCREW TRAVELS: When rotary motion is applied to the b/b nut, the screw glides along its longitudinal axis on rolling steel balls, converting rotary force and motion to linear force and motion with unprecedented efficiency.

LET SAGINAW'S EXPERIENCED ENGINEERS HELP SOLVE YOUR SPECIAL APPLICATION PROBLEMS • JUST WRITE OR PHONE US—NO OBLIGATION

Saginaw ball bearing Screw

SAGINAW STEERING GEAR DIVISION • GENERAL MOTORS CORPORATION • SAGINAW, MICHIGAN

Circle 450 on Page 19

STOP, ADMIRAL WHITEHEAD! ...DON'T SHOOT

THERE'S ONLY ONE OF THOSE IN EXISTENCE!

No need to worry. One more, or a thousand, of these special Reuland Power Packages could be quickly produced. The original drawings are permanently filed in our famous *Special-Motor Library*.

Requests for single, specially-designed, units such as this are almost an everyday occurrence at Reuland. Too, such orders are more than welcome whether there is a possibility of production quantities, or for a prototype only.

Whether *your* needs require a special design from the ground up, or a mere adaptation... one unit or many... just send us a brief resume of your problem. Reuland's "Xpandable" basic motor design permits the use of rare imagination in tailoring such power packages to exact needs... and its competitive cost makes it totally unnecessary to "make something do."

Often, we can easily provide a sample power package for approval... no obligation, other than to test it to your fullest satisfaction.

THE REULAND POWER PACKAGE SHOWN ABOVE is used to power a screw-conveyor bag filler. A primary motor (5 h.p., 1800 R.P.M., foot mounted) turns the screw for high-speed filling. After the bag reaches 92% of allotted capacity, a 128 R.P.M. Motoreducer takes over for final, precision filling. The two motors are tied into a magnetic clutch which is automatically activated by a weighing scale and electrical device.

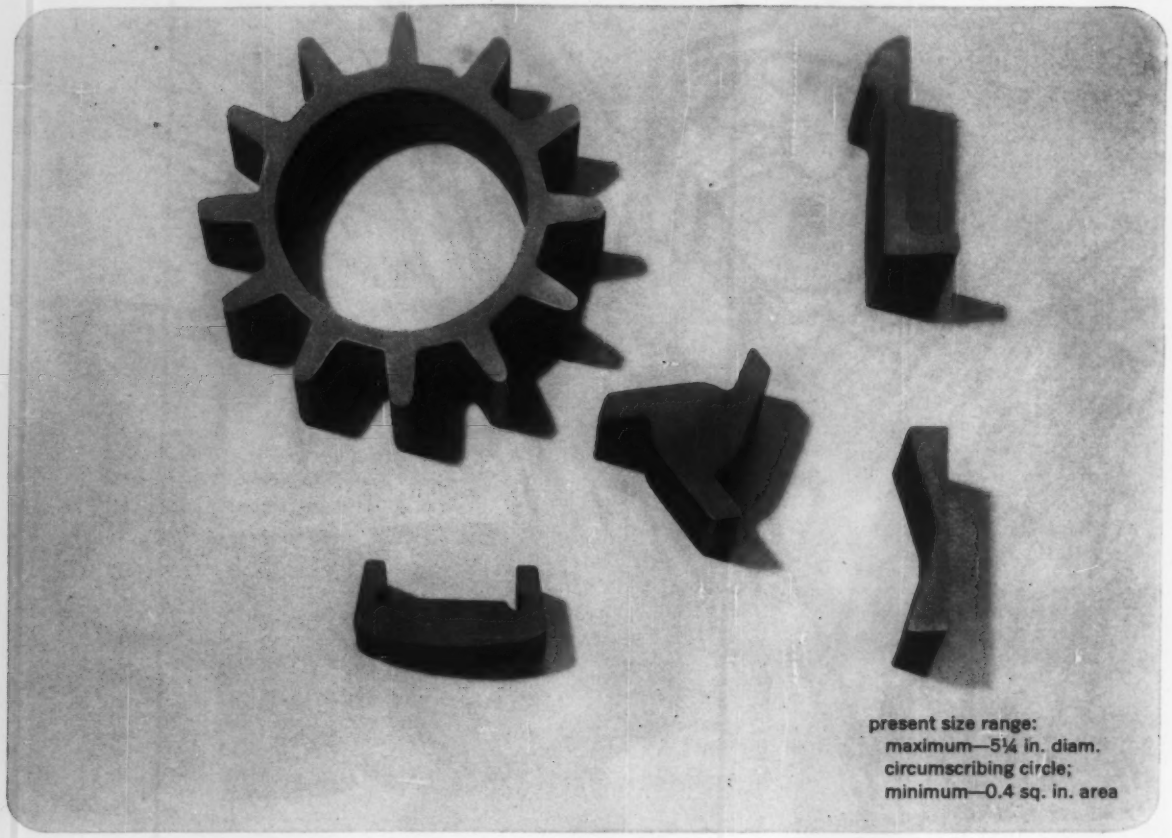
Our new general catalog will come in handy. Sent free on request. Describes the exclusive Reuland "Xpandable" design idea... Tells how you can benefit by using our free Special-Motor Library.

MODERN POWER FOR MODERN DAY PRODUCTS

REULAND MOTORS

REULAND ELECTRIC COMPANY
Western Division: Alhambra, California
Eastern Division: Howell, Michigan
Distributors in all principal cities.

Experience**—the added alloy in **A-L Stainless, Electrical and Tool Steels



present size range:
maximum—5¼ in. diam. circumscribing circle;
minimum—0.4 sq. in. area

- 316 Stainless
- 304 Stainless
- Tool Steel Atlas 93
- SAE 4130
- 410 Stainless

Why hog out intricate shapes like these? Let A-L extrude them in any steel

If you're hogging out sections, paying for special mill rolls on small orders, or waiting for minimum rolling mill tonnages, Allegheny Ludlum Steel Extrusions are your answer. They will save you scrap loss, slash your machining costs, hold down your inventory requirements and cut delivery time.

Extruded shapes save money on expensive materials and on costly machining. Non-ferrous applications in the last decade have proven it. Now even greater savings are possible with tough, strong metals in Allegheny Ludlum Steel Extrusions.

Intricate extruded shapes in all stainless grades, tool steels, carbon steels, electrical steels, high temperature alloys, even zirconium and nickel alloys are now in production at Allegheny Ludlum, cutting costs in many different industries.

Costs and minimum order quantities are surprisingly low. Charge for die design is under $200. Orders taken for as little as 40 pounds.

To learn more about the time and cost-cutting possibilities of Allegheny Ludlum Hot Steel Extrusions, send for the extrusion booklet—12-pages of design and engineering information with process and product explanation, material properties, design tips and limitations, tolerances, order instructions, etc. Or call any A-L office for technical assistance. ***Allegheny Ludlum Steel Corporation, Oliver Building, Pittsburgh 22, Pa.*** Address Dept. MD-6.

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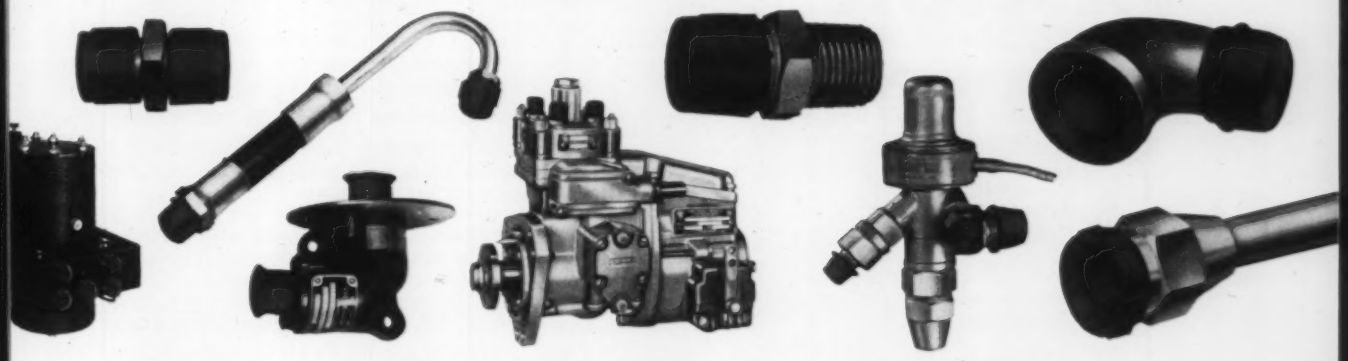

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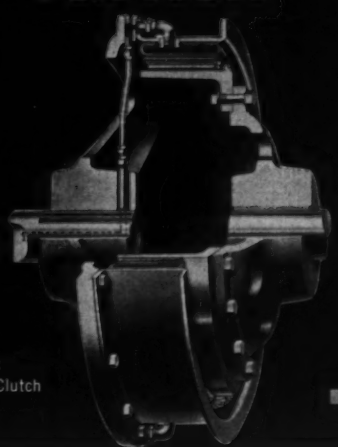

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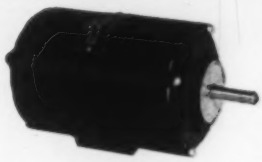

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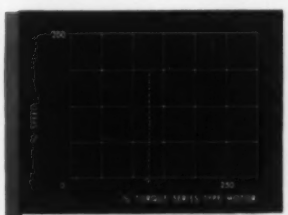
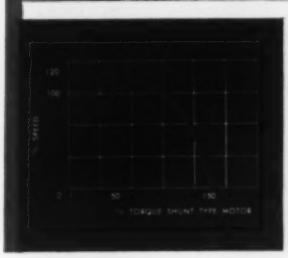


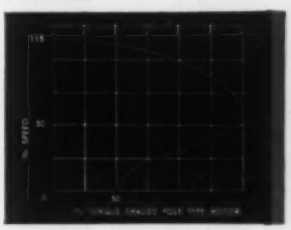
Series Type
Power: DC and AC 25 to 75 cycles.
1. High No Load Speed.
2. Full Load Speed (Optimum Performance) at approximately 50% no load.
3. Starting Torque high, 200 to 300% full load torque.
4. Variable speed, speed decreases with increasing loads.



Shunt Type **Power:** DC only.
1. No load and Full load speed are adjustable by winding or by armature and/or field voltage control. Approximately a 2:1 speed range can be obtained by field control, and 10:1 by armature control.
2. Fairly constant Full load speed.
3. Regulation varies from 10% to 30% depending upon duty and power requirements.
4. Starting torque, approximately 150 to 200% of Full Load.

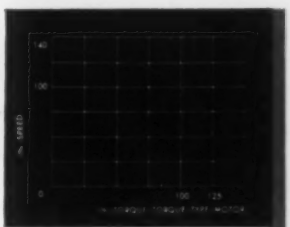
SHADED POLE MOTORS

Power: AC 50 to 60 cycles.
1. No load speed is determined by the number of poles with a No load slip of 3 to 5%.
2. Fairly constant Full Load Speed, with a full load slip of 10 to 20%.
3. Breakdown torque approximately 150% of full load.
4. Starting torque low, 50 to 75% of Full load.

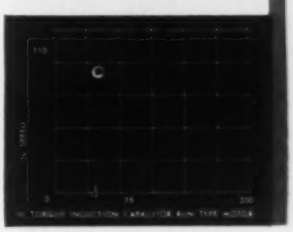


INDUCTION MOTORS

Torque Type
Power: AC 50 to 60 cycles.
1. No load speed is determined by number of poles, with a No load slip of approximately 5%.
2. Full load speed decreases with an increasing load. Designed to operate at approximately 30% full load slip.
3. No breakdown torque.
4. Starting torque high approximately 125% full load.



Capacitor Run Type
Power: AC 50 to 60 cycle.
1. No Load speed is determined by the number of poles, with a No load slip of 2 to 4%.
2. Constant full load speed, with a full load slip of approximately 10%.



Hysteresis Synchronous type
Power: AC 50 to 60 cycles.
1. Constant synchronized speed, determined by number of poles.
2. Starting torque equal to full load torque.
3. Quiet operation.

Reluctance Synchronous type motor
Power: AC 50 to 60 cycles.
1. Runs at a synchronized speed, determined by the number of poles.
2. Starting torque low, 50 to 75% of full load.

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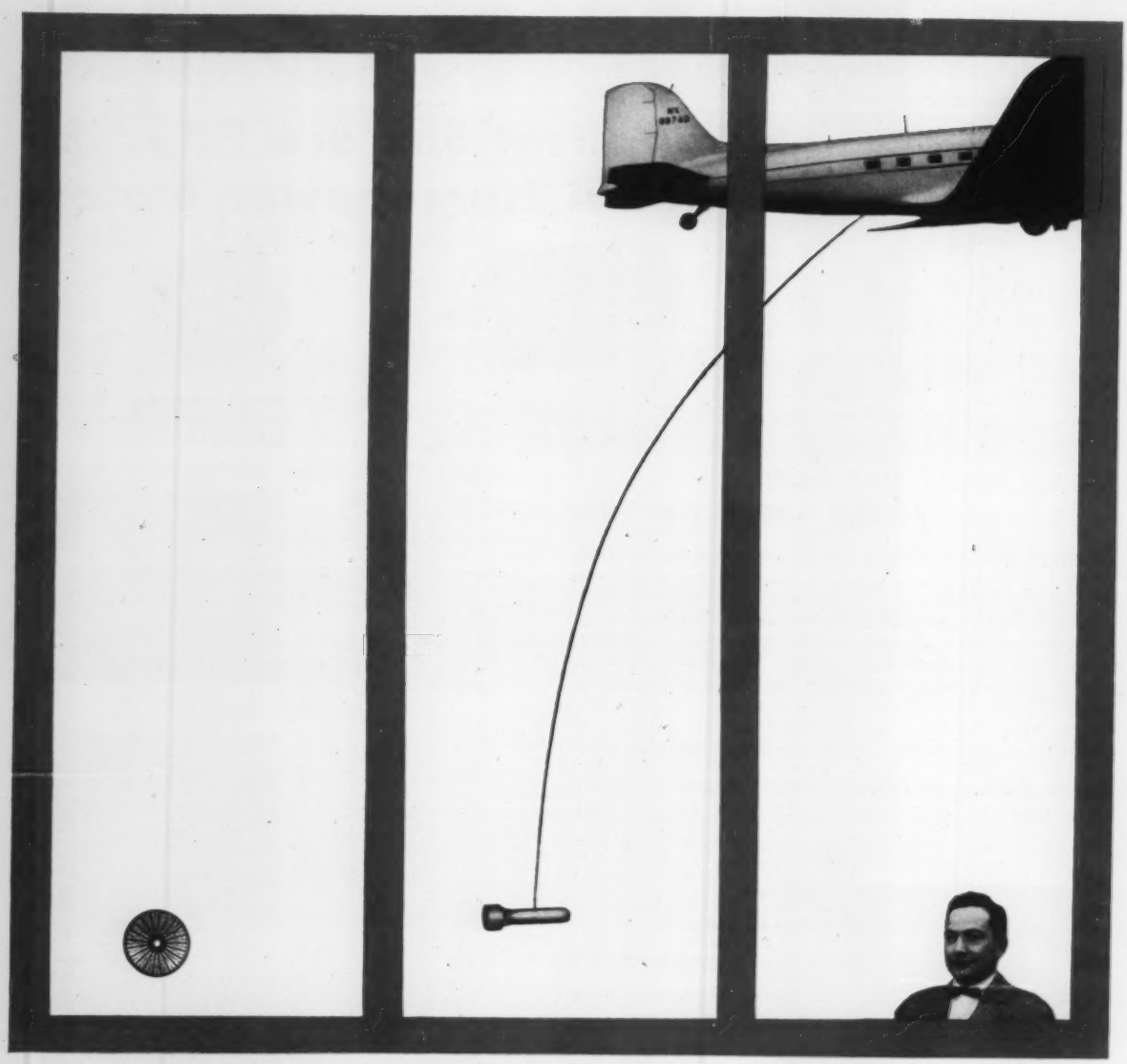

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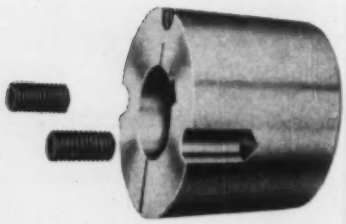

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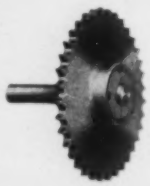
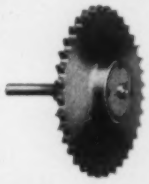
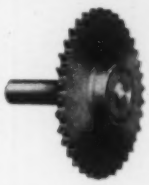
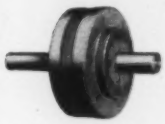
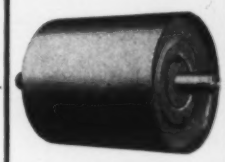
Change from shaft to shaft				
Change from size to size				
Change from sheaves to sprockets to couplings to conveyor pulleys				

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There's nothing like Taper-Lock for mounting wheels on shafts! First, you get off-the-shelf convenience. No reboring, no machining, no waiting!

● *Save Work!*

You get the holding power of a shrunk-on fit with minimum effort. Product and bushing slip on the shaft as a unit. Tighten the screws—and you're set!

● *Save Money!*

You save big money by minimizing down-time with *quick* changes. And interchangeability minimizes inventory. Note that all of the above installations are handled with a total of only four bushings—all with the same outside diameter!

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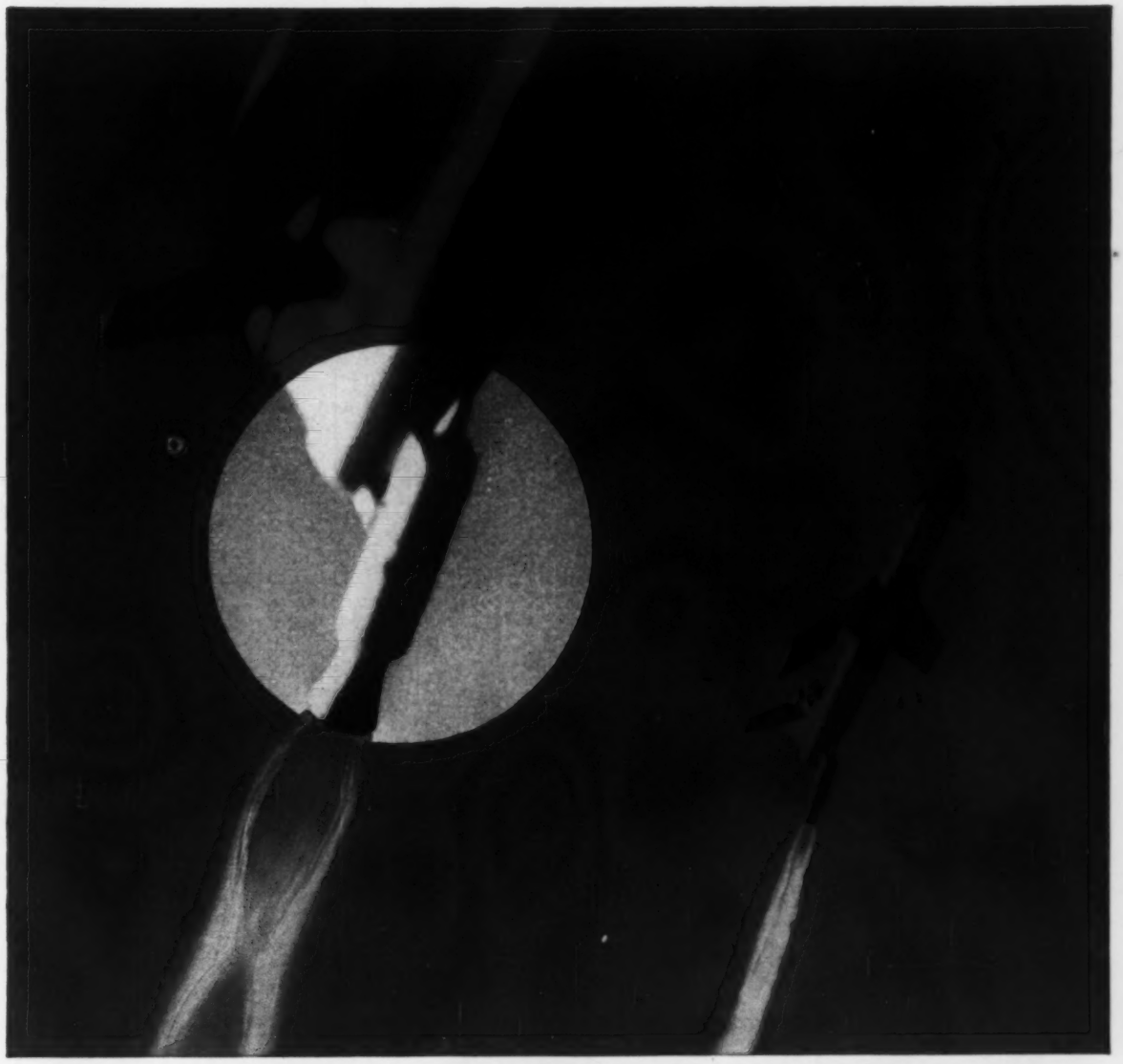

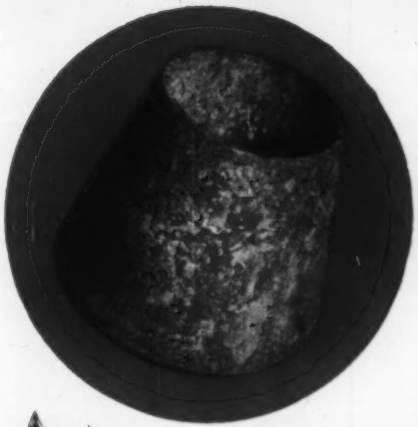

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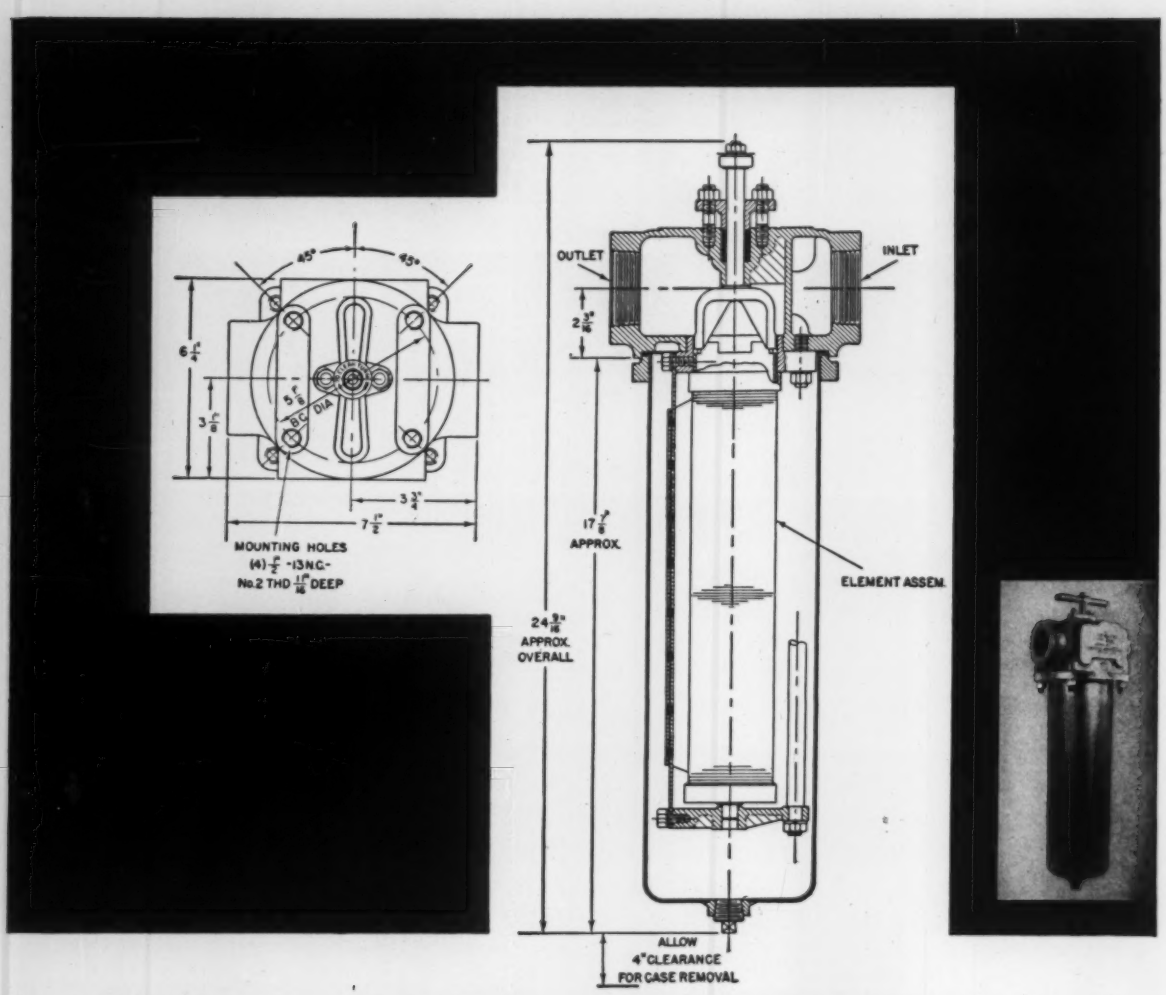

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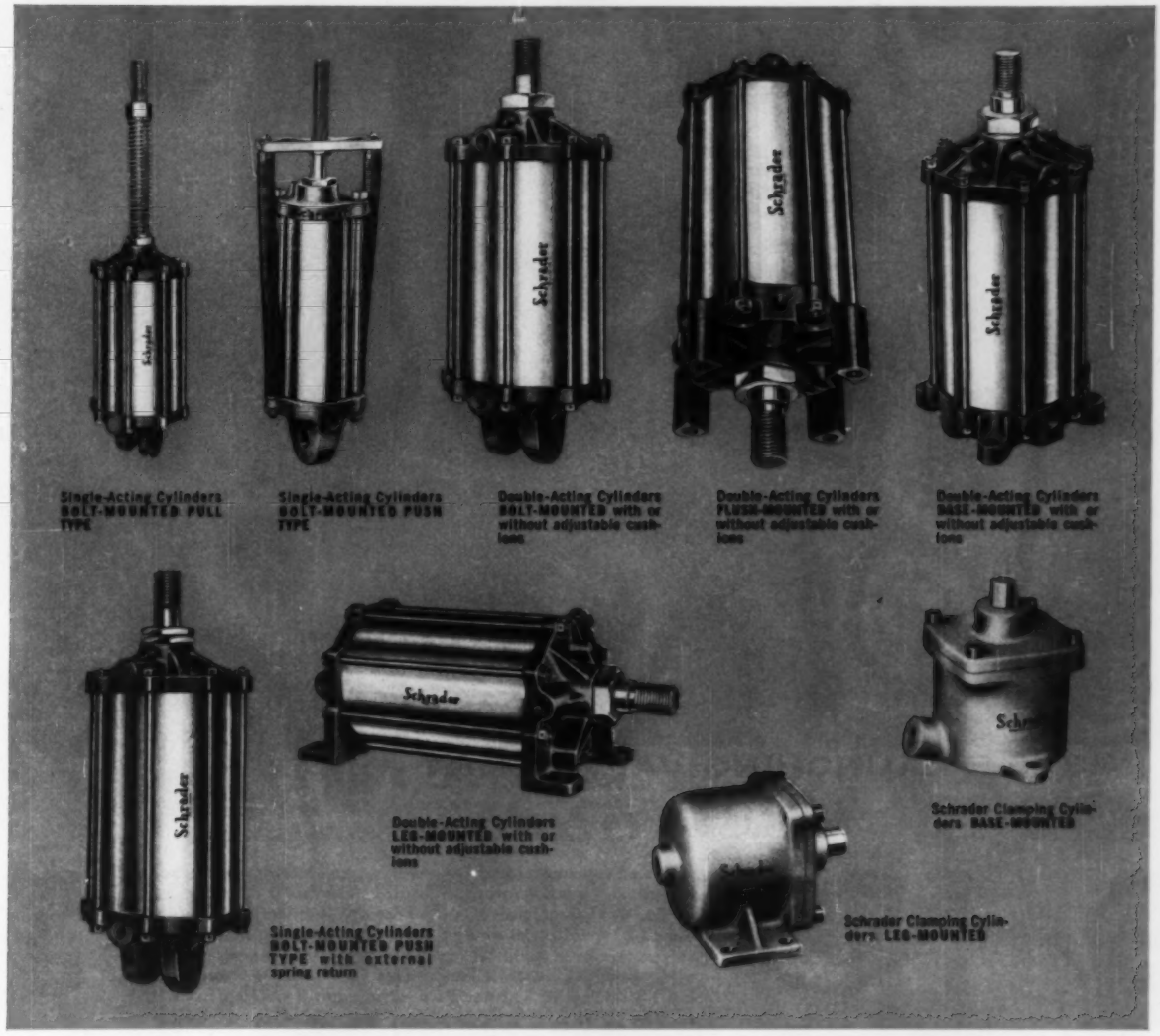
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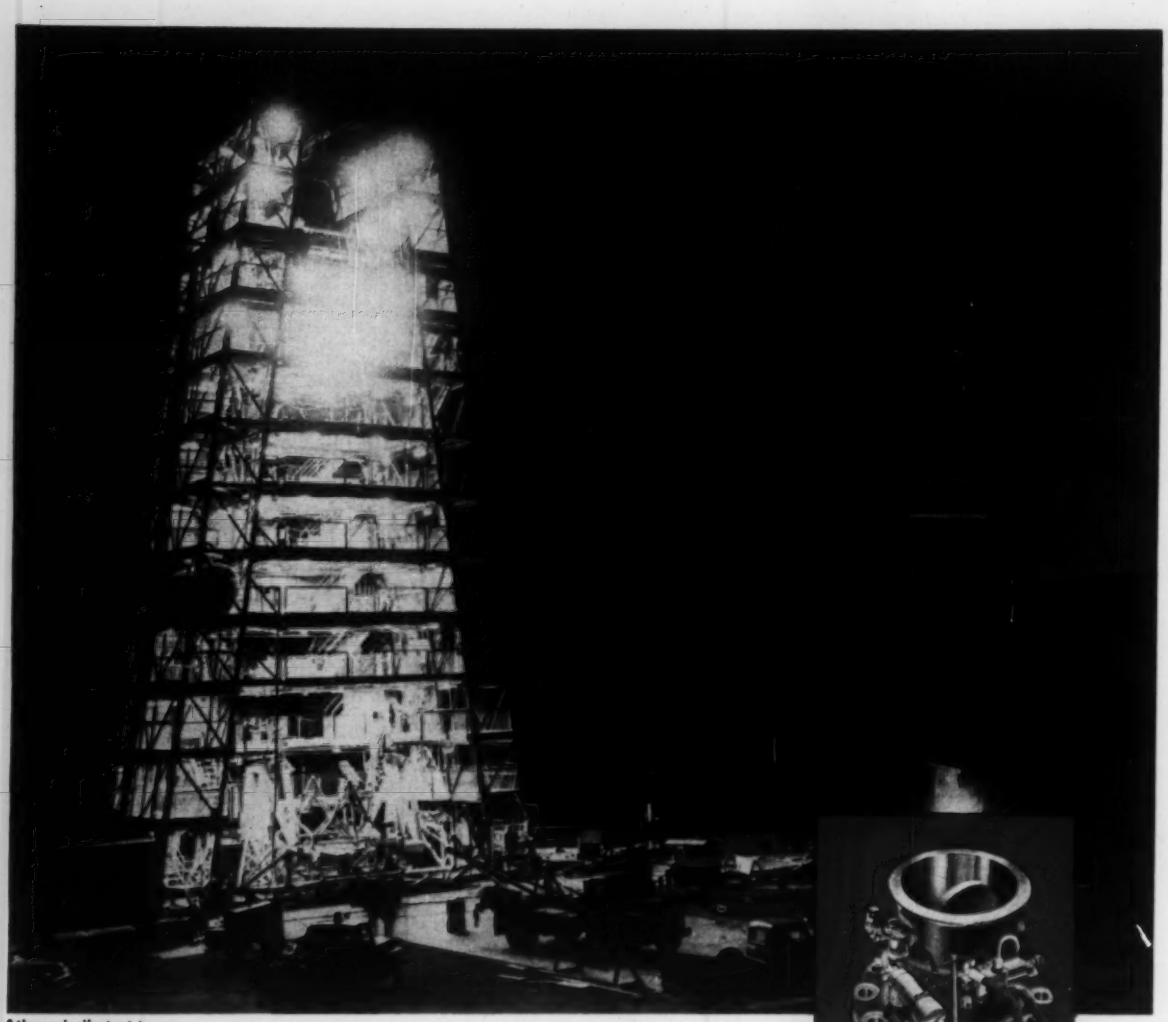

Atlas missile test tower

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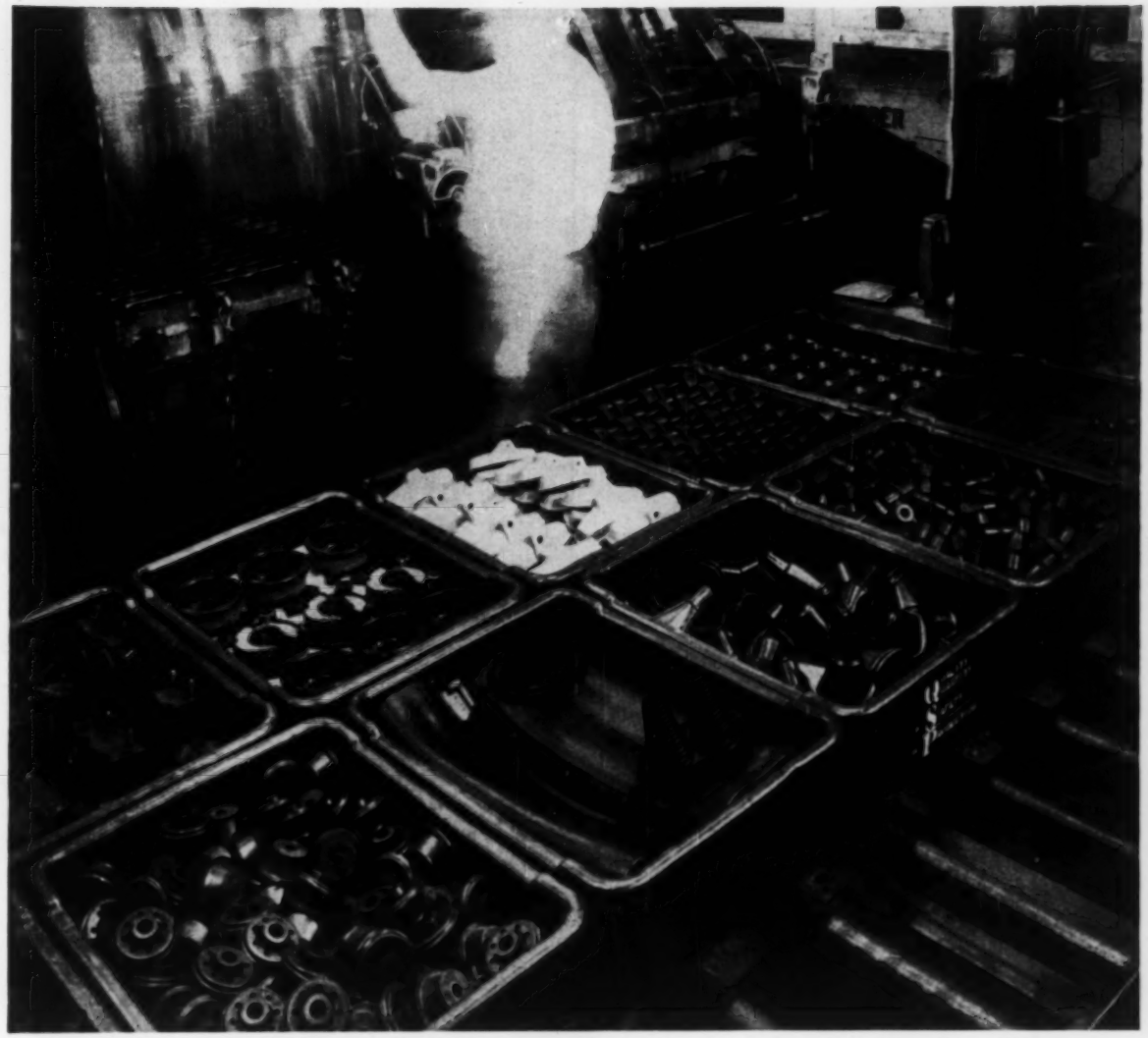

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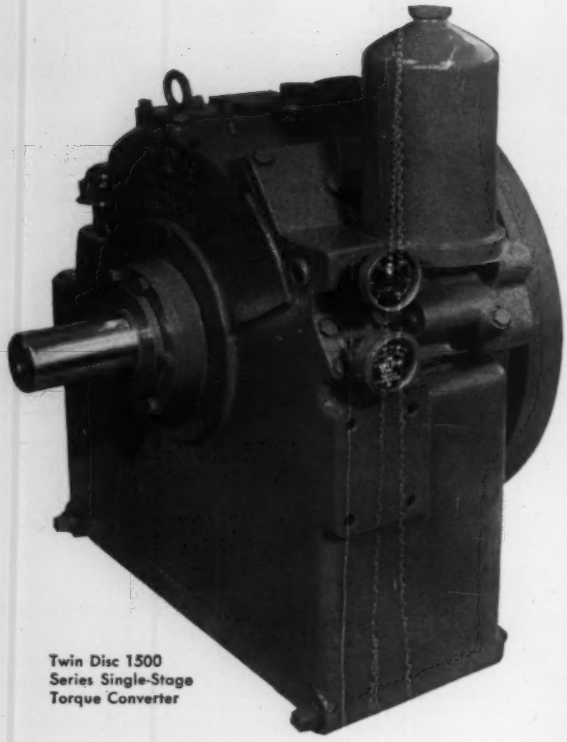


Twin Disc 1500
Series Single-Stage
Torque Converter

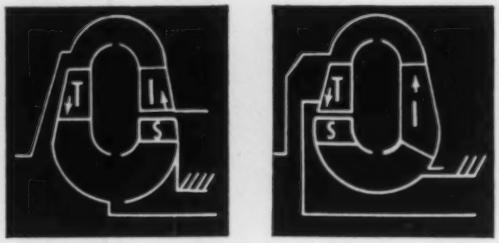


FIG. 1

Schematic drawings of the two types of single-stage circuits. The Type 1 (outflow) circuit is at left. Type 6 (inflow) is at right.

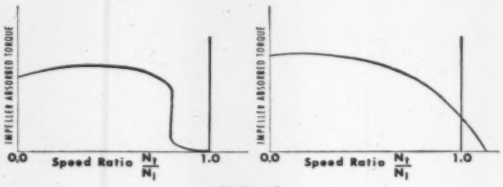


FIG. 2

A comparison of the torque characteristics of the Type 1 circuit (left) and the Type 6 circuit. The Type 1 circuit unloads the engine quite abruptly at a speed ratio of about .825. The Type 6 design allows a no-load speed ratio of 1.15:1.

Match the converter to the machine ...not the machine to the converter!

Twin Disc offers its customers the choice of two different circuit designs in each series of single-stage torque converters. The two circuit designs fit within the same housings since the circuits have the same basic dimensions. Each circuit has, however, distinctly different performance curves enabling machine designers to:

Match the converter to the machine
NOT
the machine to the converter

Figure 1, above, shows schematic sketches of each circuit. Both have the identical pear-shape convolution, the principal apparent difference being that the position of the stator is shifted. This shift causes considerable difference in the absorbed torque of the impeller.

The Type 1 design "unloads" the engine quite abruptly at a speed ratio of approximately .825. In effect, the converter becomes its own output shaft governor. Since the circuit absorbs almost no power at 1:1 speed ratio, a lock-up clutch between the turbine and pump may be incorporated in the mechanical design.

Where applications require a broader speed range in converter drive, the Type 6 circuit is recommended. As shown in Figure 2, this design allows a no-load speed ratio of 1.15:1. Torque absorption at stall is also higher, which results in higher stall torque up to 3.5:1.

For further information as to how these circuits can be adapted to your particular design, write or call Twin Disc Clutch Company.

TWIN DISC
CLUTCHES AND HYDRAULIC DRIVES

TWIN DISC
Torque Converters

TWIN DISC CLUTCH COMPANY, Racine, Wisconsin (Hydraulic Division) Rockford, Illinois

Circle 464 on Page 19

MACHINE DESIGN
June 26, 1958

Wanted: More Time

HAVEN'T got the time" seems to be the chronic complaint of our era. No time for thinking. No time to evaluate past progress. No time to plan future action.

Let's face it. For most of us, there never will be enough time. We're perpetually faced with a hundred minor tasks. And the dozen or so worthwhile things we really should get to—well, maybe we will, but probably not.

A "for instance": Starting on the next page is a survey report on the number of engineers who write articles and papers. The results? Comparatively few write. Why? Not enough time. Does engineering management try to encourage this type of professional activity? Generally, no. Why? No time available. Yet engineers and managers alike concede the importance of dissemination of technical knowledge—for the individual, the company, and the nation.

What's the answer? There really isn't any pat formula for "buying" time. A flurry of speed may get one over the rough spots. Careful, tight-paced scheduling helps—if the personal strain isn't too great.

But these methods are only poor stopgaps if we violate a fundamental rule: *Put first things first.* Too often, we fail to ask the question: What's the most important thing I can do next?

Of course, we can't ignore the bread-and-butter details that must be done, and done well. But a sensitive awareness of what's important, and what isn't, carries with it an urgency to dispose of details with dispatch.

We'll probably always complain that we "haven't got enough time." But we can gain one thing—a sense of satisfaction that the precious little time we do have is well spent.

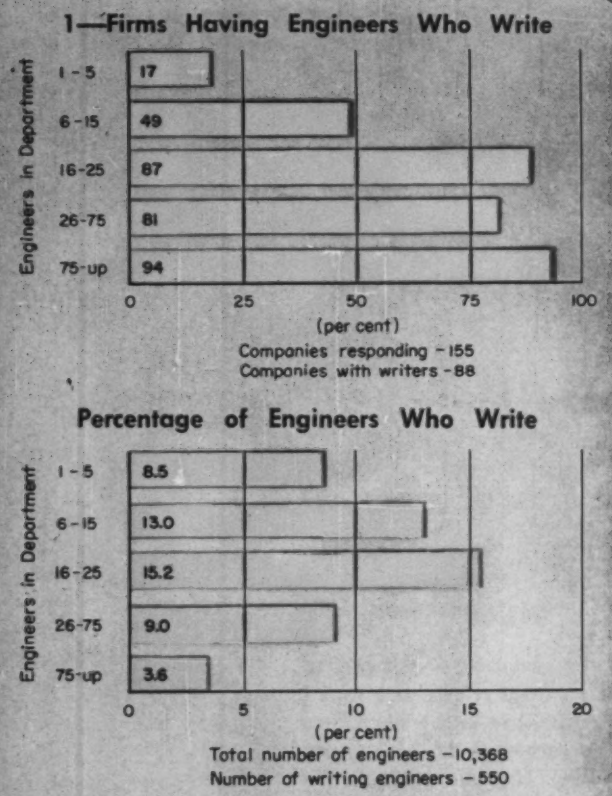
Robert L. Stedfeld

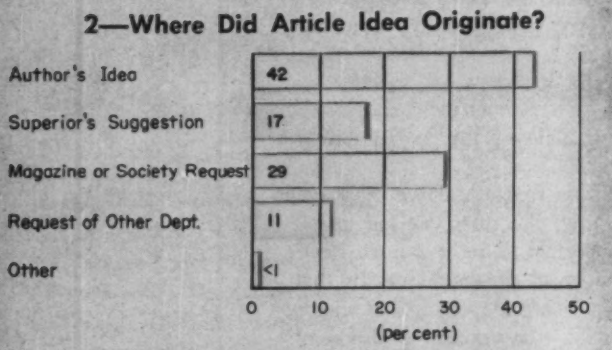
ASSOCIATE MANAGING EDITOR

TECHNICAL

By MICHAEL K. BONNER
Vice-President
Harry W. Smith Inc.
New York, N. Y.

The author and the editors of *Machine Design* recently conducted a survey to gage the amount of writing being done by engineers and the management policies and opinions concerning technical communication. As expected, the vast majority of firms are in favor of writing—and the vast majority of engineers do no writing. An analysis of some of the whys and wherefores of the situation have led to suggestions for its improvement.





"In practically every case we ask our people to prepare papers—or someone else does."—*Vice-President Engineering, Instruments and Controls*

"Each department head assigns engineers to technical writing projects."

"An available roster is kept of engineering personnel interested in making speeches . . . ."—*Assistant Chief Engineer, Airframes*

"For those few doing article writing, it is part of their assigned work."

"We prepare papers only as the result of demands which we cannot disregard. We could spend a considerable amount of time writing articles and giving papers if we did not have work to do for the company. We have many requests that we cannot grant. In thirty years we have prepared 206 articles and papers."—*Vice-President, Textile Machinery*

ENGINEERING achievement is a product of capital, organization, and incentive. However, in each field of engineering, one of the fundamental ingredients of achievement is technology —what is known, the rapidity of learning, and use of the knowledge.

The major responsibility for communication lies with the individual engineer, who must both originate and apply technology. Development of many narrow and complex technologies, and continuing refinement and change, demand that the engineering specialist take part in transmitting technical information to others. Professional accomplishment is not enough; the engineer must often write or speak about what he knows. Conversely, as a user of technical information, he is most productive when he maintains broad, up-to-date knowledge of techniques, components, materials, and services developed by other specialists and of possible value to him.

Benefits From Writing: Activity as both a source and user of technical information benefits the engineer, his company, American industry, and the United States as an industrial nation and world power. The engineer himself profits both by speeded advancement within his company and increased professional stature in his field.

The engineer's company benefits by any activity which develops any complementary skills, such as writing, which extend his professional capacity and the range of his work activities. Transmis-

WRITING BY ENGINEERS

. . . the present situation and suggestions for its improvement

sion of technical information is extremely vital in selling a company's products and services to its markets. Many complex, specialized products are difficult to evaluate technically before purchase and are therefore bought partially on the engineering reputation of the company. That reputation is built both on prior performance of the company's products and on the stature of its engineers as evidenced by their articles and papers. Published articles on application of a company's products have a direct value to actual and potential customers.

American industry and the United States benefit from effective exchange of technical information in two ways. First, the creative-engineering process multiplies many-fold through pooling of ideas and discovery. Second, costly and time-consuming duplication of effort is minimized by more universal sharing of discovery and development.

Writing Activity of Engineers: Recognizing the benefits of continuing activity in originating technical information, are engineers doing much article writing? In general, the answer is "No." Most engineers do not consider the preparation of technical articles and papers a basic phase of their professional life, although they feel responsible for keeping abreast of technical developments that are reported by others in their fields. Consequently, most engineers very rarely—or never—write a technical article or appear on a professional-society program.

Burden of the technical-communications job is being carried by an extremely vocal minority. Nearly every engineering specialty has familiar authors and speakers who time and time again contribute technical information that is useful to other engineers. These men are only a fraction of those many engineers whose experience would be valuable to others in their profession.

Have engineering managements emphasized their engineers' responsibilities as sources of information and encouraged and rewarded accomplishment? In general, they have not. The policies of individual engineering managements vary from recognition of writing and speaking as part of the engineer's day-to-day job, to outright discouragement. Engineering executives who encourage writing articles and presenting papers cite many individual and company benefits. Those who discourage the communications function of the engineer have reasons which they feel are equally sound.

The MACHINE DESIGN Survey: A survey was recently conducted among engineering executives in 850 companies that formed a representative sample by industry, size, and geographical location. Of those contacted, forms were returned by 170 companies, employing from two to 2612 engineers. All but 15 of the respondents provided sufficient information for use in statistical summaries and almost all the returns included at least one additional comment. The unusual rate of return on the survey (20 per cent is high for mail surveys) and the positive, sometimes outraged, nature of many of the comments indicates that, whatever their policies may be, engineering executives have seriously thought about the engineer's function and responsibility in technical communications.

Since the number of companies in the survey sample is too small for a realistic quantitative projection, no attempt is made to draw any significance in actual numbers. However, a number of valid qualitative observations can be drawn.

1. An average of only 5.3 per cent of engineers write, the survey revealed. This is rather low (although there is no standard of comparison) and, in departments with less than 75 engineers, quite uniform, Fig. 1. However, averaging has covered up a surprisingly wide variation in the article output from particular companies. To cite a pair of extremes, one company of 26 engineers produced a total of 40 articles and papers in a year, while another company with 700 engineers produced 8 articles and 2 papers.

2. The engineer-writer rarely turns out more than two articles or papers in a year. Among the companies with writers, 550 engineers produced 832 articles and papers, an average of 1.51 per man per year.

3. Most articles orginated as an idea of the author's, with little suggestion from engineering management, Fig. 2. Engi-

neering journals and professional societies have been helpful in requesting almost a third of the articles prepared.

4. Most engineering executives do not consider articles and papers a regular responsibility of engineers, but many encourage writing. Of those who feel writing is a responsibility, three-quarters have stated so formally to the department, Fig. 3.

5. Article writing may be an indication of advancement potential, depending on the individual engineer, Fig. 4. Some engineering executives are rather skeptical about engineers' motives in writing, and other carefully differentiate between engineering and writing abilities.

6. Use of company time for writing is usually left up to the judgment of the individual engineer-writer. However, the consensus seems to be that there is little or no company time for him to assign anyway, Fig. 5.

7. Almost all the companies are happy to help the engineer-writer with stenography, illustration, and editing once he has decided to write, Fig. 6.

8. An engineer-writer is usually rewarded by his superiors and company with recognition of some form; only one-fifth of the companies surveyed did absolutely nothing, Fig. 7.

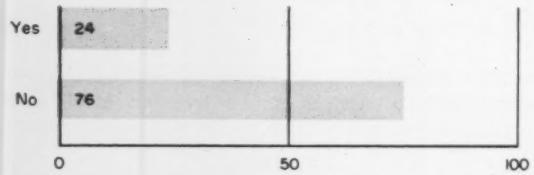
9. Few companies pay the engineer-writer for an article; among those that do, there is a large variation in rate of compensation.

10. While no engineering executives consider authorship the only reason for a salary increase, many feel it is an important contributing factor.

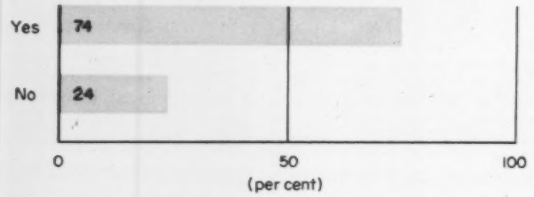
11. Many companies recognize that they should be doing a better job in technical communications, Fig. 8.

Quotations which are relevant to each of these points are reproduced in Fig. 2 through 8 exactly as written by the respondent. His title and the company industry or products are given when this information was filled in on the form. Comments both support and oppose strongly the statistical consensus in Fig. 1; opposition is particularly evident in Fig. 2. The particular comments quoted do

3—Is Writing a Regular Responsibility of the Engineer?



If So, Has This Been Stated Formally?



"Not considered a responsibility, but is considered highly desirable, and our engineers have been so informed."—*Vice-President, Process Instruments*

"I do not consider it a responsibility but do feel it is an aid in development."—*Vice-President Engineering, Instruments and Controls*

"We encourge this practice but our engineers are usually extremely busy."
"They are given all encouragement and we pay expenses for them when they give a paper, even at the World Power Congress."—*Chief Hydraulic Engineer, Pumps*

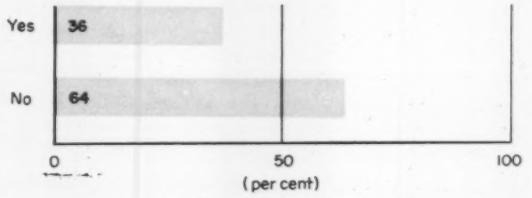
"Anyone showing an inclination will get encouragement."
"We consider this beneficial for both the engineer and the company, and so advise those who have the potential and a worthwhile subject."—*Chief Engineer, Military Radio & Electronic*

"Yes—verbally and in writing."
"Of course, as this is considered extra-curricular work, we do not force the issue."—*Plant Engineer, Heat Transfer Equipment*

"Most of the articles written are for company publications, not for public magazines, etc."—*Supervisor-Mechanical Engineering, Automatic Machines*

"If articles seemed worthwhile, would be given all help and encouragement."
"Don't consider writing a responsibility of all; just of those whose work is suitable for publication."—*Chief Administrative Engineer, Aircraft Engines and Components*

4—Does Inclination to Write Indicate Advancement Potential?



"The ability to clearly project one's insight into an analysis of a problem is definitely an asset. However, I am personally acquainted with several highly talented and creative engineers in top administrative posts who usually rely on someone else to write their letters."—*Chief Engineer, Materials Handling Equipment*

"Depends to some extent on whether a particular individual's potential lies in a technical or managerial direction."
"We find it necessary to *urge* the engineer to prepare papers."—*Chief Engineer, Military, Radio and Electronic Equipment*

"We would be happy if our engineers were interested in the professional societies in any way."
"Quite often the man who wants to write is not well qualified."—*Chief Hydraulic Engineer, Aircraft Hydraulic Equipment*

"Some of the finest engineers are reticent about having their names appear in print."
"Inclination may be due to interest in a very specific problem which does not necessarily indicate advancement potential."—*Chief Engineer, Chemical Processing Equipment*

"Initiative and the knowledge that communication of ideas leads to the advance of technology show potential."
"Eager beavers are looking for ways to attract attention and papers or articles is our one accepted means."—*Vice-President Engineering, Electric Motors*

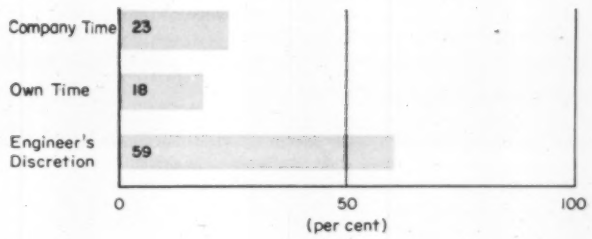
"Our best designers are not our best writers."
"Yes, but they regard papers as a burden which they are inclined to avoid."—*Vice-President, Textile Machinery*

not represent the balance of opinion but are only an arbitrary sampling.

No matter how they answered the questions in the survey, most engineering executives can immediately pinpoint reasons for their present technical-communications policies (if there are any) and the amount of article writing that is being done. These policies are in large measure products of unique mixtures of tradition, inertia, personalities, department size, type of engineering, and security regulations. However, for virtually all engineering departments where writing is far below their potential, there are common factors that concern both the individual engineer and the company management.

The most frequently expressed reason for insufficient writing is simply lack of time, Fig. 5. The regular work load and continuing pressure for results from management mean extra hours for engineers at the plant and at home as it is. Many cannot find time to do an adequate job in studying pertinent articles written by others, much less do any writing themselves.

5—When is the Writing Done?



"Normally would expect a large share to be done on company time."—*Vice-President, Engineering, Instruments & Control Systems*

"At individual engineer's discretion, but not to interfere with day-to-day job."
"Unfortunately, work load does not permit the writing of articles on company time."—*Chief Hydraulic Engineer, Aircraft Hydraulic Equipment*

"We have granted permission to do, say, about 25% of the required work on company time."—*Chief Hydraulic Engineer, Pumps*

"Although the actual preparation of the article is supposed to be done outside of work hours, the data for an engineering type of article is obtained on company time and comprises most of its total time."—*Vice-President, Process Instruments*

"There is not a set procedure on this. Subjects relating to work other than the company's should be done at home."
"At individual engineer's discretion . . . . as time and energies permit."—*Chief Engineer, Packaged Boilers*

"Usually it's done partly on company time and partly on own time, because his normal duties don't afford sufficient leeway to do it all on company time."—*Chief Administrative Engineer, Gas Turbine Engines*

"Would like to be able to have sufficient company time available."—*Vice-President Engineering, Electrical Components*

"We expect author to use some of his own time so as to allow normal activities to proceed."—*Chief Engineer, Fuel Burning Equipment*
"Pressure of work with minimum personnel precludes possibility of writing on company time."—*Plant Engineer, Heat Transfer Equipment*

"Company time is permitted but 'homework' will be required if the job is well done."—*Chief Engineer, Carburetors and Fuel Injectors*

How to Encourage Writing: An engineer's professional life is not so inflexible, however, that he cannot find time to write articles and papers if he thinks writing is important enough. His evaluation of its importance may simply reflect engineering management's own attitude. Thus, an engineer who does little or no writing may well be receiving little or no encouragement—which need not involve allocation of time but simply a statement of policy, help in planning, and recognition of achievement.

Implied in many comments in this survey are a need for more self-confidence as writers or speakers and a better understanding of the magazines and professional societies in their fields. Most engineers claim they cannot write or speak very well. Many are simply too modest; they turn out to be excellent writers and get better with each effort.

Understanding a technical journal or professional society is primarily a matter of judging the technical level and range of interests of the readership or audience. For example, many engineering specialists seem to avoid writing at less than the highest technical level possible. Apparently, when communicating with engineers who are not specialists in their field, they feel that the treatment of fundamentals reflects upon their own level of understanding.

Whether intentionally or not, engineering managers are primarily responsible for the level of technical communications in their departments, whether the output of articles and papers is relatively high or low. Only a few concepts need be established by engineering management to eliminate neglect or discouragement of technical articles.

1. Avoid when ever possible, budgetary or employment situations which allow the individual engineer no freedom to assign his time for writing.
2. Recognize today's increased need for universal participation in exchange of technical information and discard old attitudes of professional isolation.
3. Realize that writing articles and papers is a professional rather than a personal activity.
4. Maintain writing activity, even if on a reduced basis, during periods of temporary work overloads.

Joint Planning Is Necessary: In view of the importance of technical information in selling the company and its products, it is surprising that less than one-third of the articles and papers reported in the survey were initiated by a superior or another department. There are few companies selling to industry where publication of technical articles on significant engineering developments would not materially help sales. When these opportunities are lost, it is usually because the sales and engineering are

isolated and therefore, engineering does not know the marketing objectives and problems.

The Active Engineer-Writer: The naturally communicative engineer writes articles and presents papers because he personally feels it is important to himself and to his company. Presence or lack of encouragement by engineering management has little effect on his output. Since his communicative instinct may provide his company's entire article output, he carries a great responsibility.

The engineer-writer is usually concerned with a project he has just completed or a specific subject he feels he knows particularly well. Joint planning is necessary to assure that the self-starting engineer will write on subjects that will be good for the company.

Magazines and Societies Help: The survey indicates that magazines and professional societies perform a large share of the encouragement of exchange of technical information as part of their business function. Many engineers who never considered writing become authors at the suggestion of technical editors or papers committees. Magazines search for useful editorial material and find authors and develop articles on significant developments that might not otherwise be widely known.

Direct Compensation: There is firm disagreement on policy about direct compensation for articles and papers. Among those companies who do pay their own engineers for articles, there is a wide variation in the amount—from $50 to $600 per published article. One company makes a ceremony of presenting checks to authors; another has a rule of no compensation. The survey does not show how successful the direct-compensation plans have been or whether or not companies who do pay for articles have been substantially more successful in developing authors.

There are several points in favor of payment to authors of articles and papers:

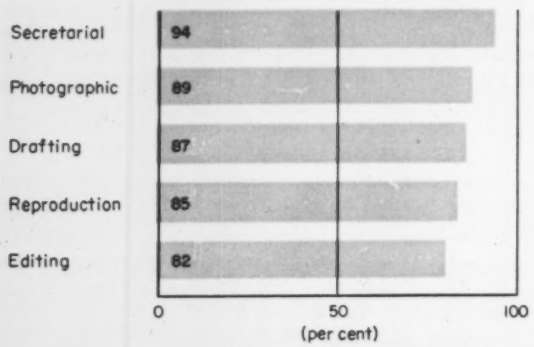
1. The engineer-writer invests skill and effort beyond his regular responsibilities and should receive some concrete recognition.
2. He undoubtedly puts a good deal of his own time into the article and the company usually benefits from its publication at least as much as the author does.
3. The sales value of a properly prepared and appropriately published article far exceeds the cost of a reasonable stipend to the author.
4. Dollars get results.

On the other hand, there are several logical reasons for a policy of no payment to authors:

1. The engineer may be writing for money first and the good of the company second.
2. Articles in major magazines are adequately paid for by the publication, and papers before professional societies usually involve a trip and a pleasant break in routine as compensation.
3. Prestige of publication and recognition from the engineering profession are the only lasting rewards.

Opposition to direct compensation for articles

6—What Writing Services are Provided?



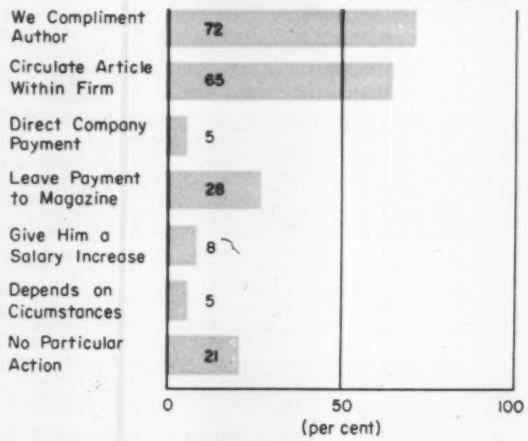
"While not specifically encouraged, all engineers have been advised that the facilities of the department are available for use at their individual request."—*Chief Engineer, Excavating Machinery Design*

"Also help in handling correspondence with the periodical (by our PR Department) or the professional society (done by me)."—*Chief Administrative Engineer, Aircraft Engines and Components*

"We require all material to be edited by a superior and by the Public Relations Department."—*Vice-President and Chief Engineer, Machine Tools*

"Probably would help, if a man wanted to present papers."—*Vice-President Engineering, Special Automatic Machinery*

7—What is Done in Recognition



"Usually the recognition by others in his profession, plus the trip to the meeting where paper is delivered, we feel pretty much outweighs the reward of a small dollar stipend."—*Chief Administrative Engineer, Air-Craft Engines and Components*

"Acknowledge article or presentation in the company news sheet."

"Through our Writing Award we encourage them to prepare articles."—*Chief Engineer, Aircraft*

"Company policy is to list and publicize within the engineering branch technical articles published and presented."

"Our house organ recognizes and encourages articles by our engineers."—*Chief Manufacturing Engineer, Electrical Distribution Equipment*

comes from both engineering executives who do not believe in it as a matter of policy and from those who have tried it with unsatisfactory results. In the latter case, failure is not caused by any basic fault in the theory of direct compensation but usually by a lack of clear ground rules which cover all types of writing activity. Foggy ground rules can create misunderstanding, resentment, and a determination not to write articles under any circumstances. Rules for payment should anticipate inevitable questions from potential authors:

1. Is the fee per typewritten page or per published page?
2. Is payment made by the company whether or not the magazine pays?
3. If essentially the same article is published by magazines in two different fields, is payment made for each?
4. Is payment made upon acceptance or publication?
5. What is the effect upon the amount if editing by the magazine cuts the length of the text?
6. When more than one author, how is payment split?

If points of possible misunderstanding are thoroughly covered and the authorship plan is properly presented, it has a good chance of at least keeping out of trouble. Presentation of such plans should make clear that a reviewing committee must approve the article and the selection of magazine before direct compensation can be considered. Payment policies of technical magazines are effective because the editors have the right (and duty) of rejection—a right which should be exercised by the reviewing committee in a company compensation plan.

Eight Steps for Management: Engineering management can adopt eight steps to build and maintain an active communications program and encourage the writing habit among its engineers. The first three steps involve initial action in setting up a program. The remaining six steps are actually management policies to assure its continuing success.

1. Establish and state formally the firm belief that article and paper writing is part of the engineer's job and will receive proportionate attention during reviews for organizational and salary advancement.

2. Inaugurate regular communications-planning meetings between management, engineering, sales, advertising, and public relations.

3. Organize a papers committee within the engineering department to carry out suggestions of the planning committee, to select possible or desired subjects, and to consult with the most appropriate engineer-authors.

4. Let the engineer decide where to find time for writing articles when he initiated the idea or took part in the original planning. If an engineer is requested to do an article for the company, company time must be allotted for the project, particularly if there is a tight deadline.

5. Give ample help in both the creative and mechanical phases of article preparation. These include secretarial assistance, photographs, drawings, planning, editing, and negotiations with publication or professional society.

6. Allocate an adequate travel budget for engineers who are presenting papers at society meetings.

7. Recognize the engineer-writer's work. Compliment him on a job well done. Announce and distribute his article or paper within the department and, if appropriate, outside the company in selling; in other words, acknowledge him as the authority he is (or should be). If necessary and consistent with policy, establish a direct-compensation plan based on simple, clear-cut ground rules.

8. Encourage the use of technical information and an awareness of magazines and societies by strengthening the engineering library and circulating pertinent articles and papers by others.

of Published Material?

"The recognition the author receives as a result of the published article should suffice. Additional compensation would encourage neglect of the company's business."—*Chief Engineer, Fuel Burning Equipment*

"In addition to $50 per published article, a certificate of recognition is presented by the company president."—*Vice-President and Chief Engineer, Machine Tools*

"Ten dollars for less than one page, $25 for one page or longer. We also make presentations of checks at appropriate company meetings."—*Vice-President, Process Instruments and Controls*

"Pay by the word, believe it is $0.05 per word."—*Executive Director of R&D, Electrical and Metallurgical Research*

"Would be opposed to financial compensation."—*Vice-President Engineering, Mechanical Presses*

"$50 per published article."—*Assistant Chief Engineer, Airframes*

"$150 per published article."—*Chief Engineer, Aircraft*

"Rule—no compensation."—*Vice-President Engineering and Research, Business Machinery*

"We compensate engineers at a rate above standard—$75 per printed page—in addition to publisher's remuneration. Our engineers realize approximately $600 gross remuneration for good, trade articles."

"Accepting compensation for articles is against company policy."—*Vice-President Engineering, Clutches and Fluid Drives*

"$50 per published article."—*Chief Engineer, Fans and Air Conditioning Units*

"Consider it a part of job—compliment him on a job well done, as we do in any other phase of work. Obviously affects pay, but not a direct consideration."—*Vice-President Engineering, Instruments and Controls*

"While not a direct factor, article writing is certainly considered in any increases of salary. Interested persons include our agents throughout the country."—*Assistant Chief Engineer, Packaged Boilers*

8—Are You Satisfied With Your Engineers' Article Production?

"Feel that we should publish more of our work."—*Manager-Research and Development, Engineering Research*

"We've been very lax in this area. At one time our management definitely discouraged technical writing for publication. Maybe we should look into it again."

"We are just starting to encourage our men to do these things."—*Chief Engineer, Machine Tools*

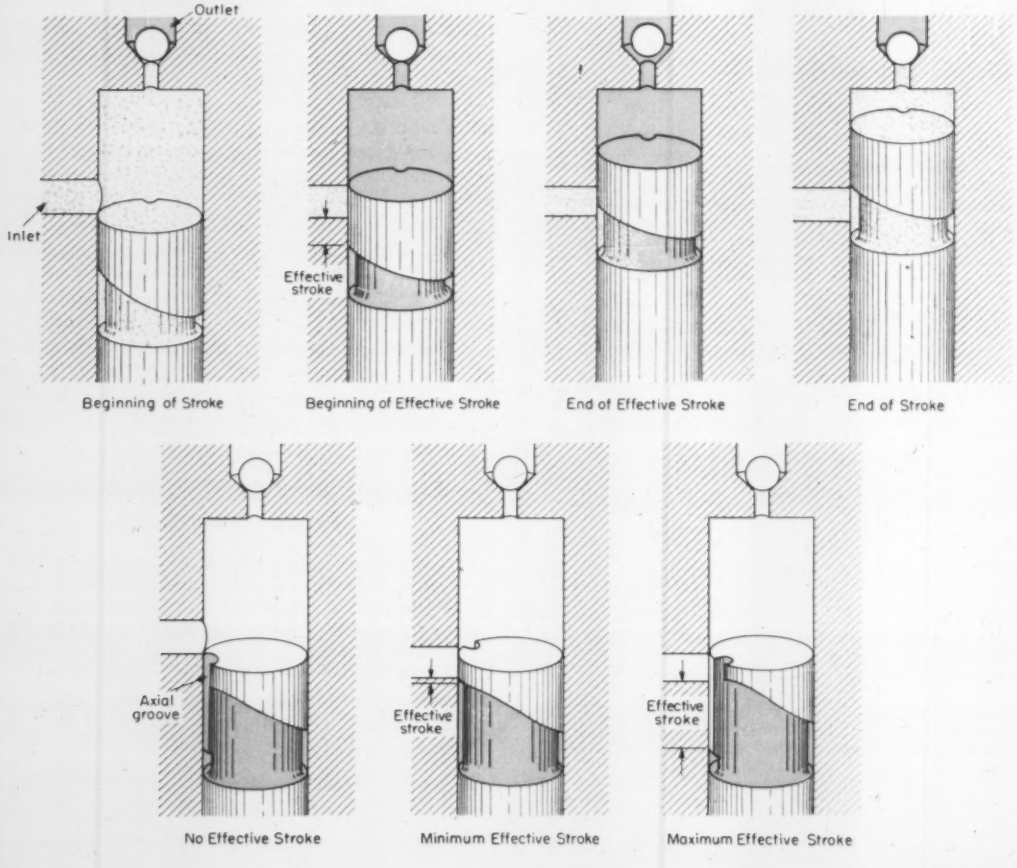
"We could do better."

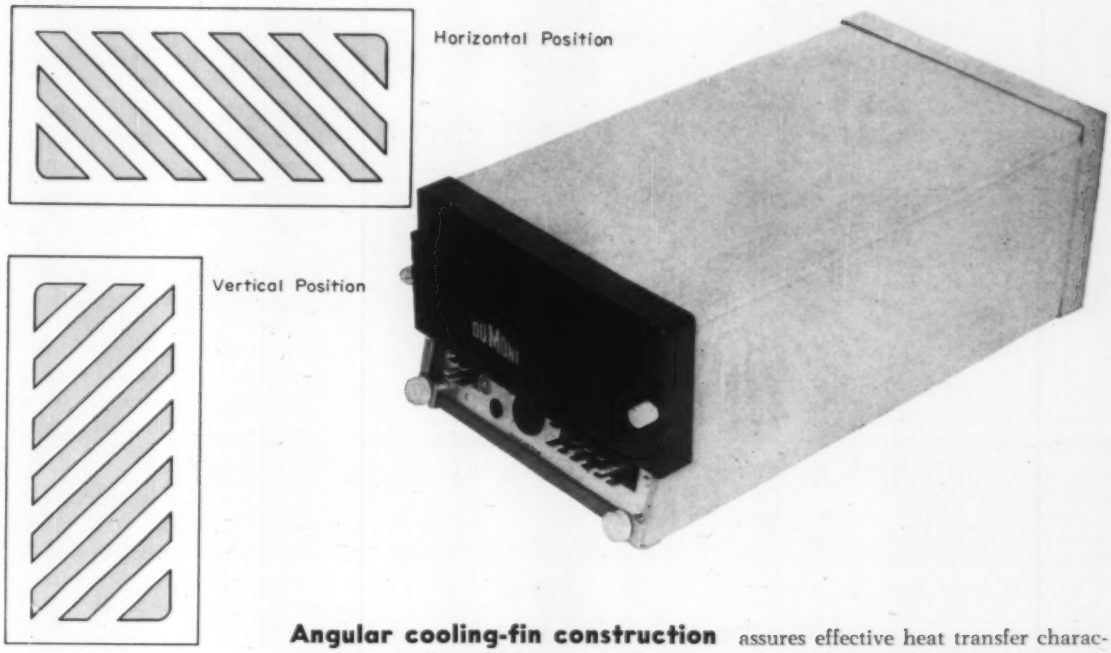
"We would be happy if our engineers were interested in the professional societies in any way."

scanning the field for *ideas*

Adjustable fluid-flow control is accomplished in a fixed-stroke piston pump by angular rotation of the piston about its axis. In a simple fluid-metering pump supplied with liquid under pressure, the intake opening is uncovered by the piston at one end of its stroke; on the power stroke, the intake is closed and the liquid is forced out of the cylinder.

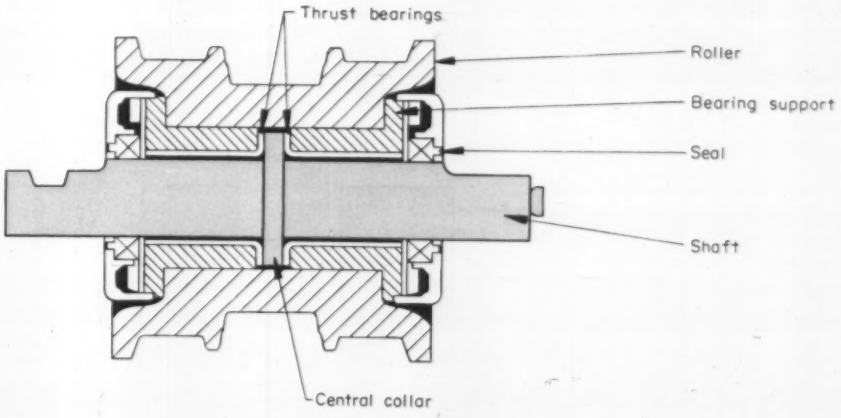
Adjustment of output is accomplished by means of a recessed pocket that extends around the surface of the piston. One side of the pocket is in the form of a helix, so that the pocket varies in width around the piston. At the widest portion of the pocket, an axial groove extends to the piston face. At the end of the effective power stroke, the helical edge of the pocket is aligned with the intake opening. Liquid not expelled from the cylinder is combined with fluid at the intake. Effective stroke is the axial width of the wall between the piston end and the helical edge of the pocket. Rotation of the piston adjusts the effective stroke and, thus, the output volume. The design was developed by Engineering Engine Div., Caterpillar Tractor Co. for a fuel-injection pump.

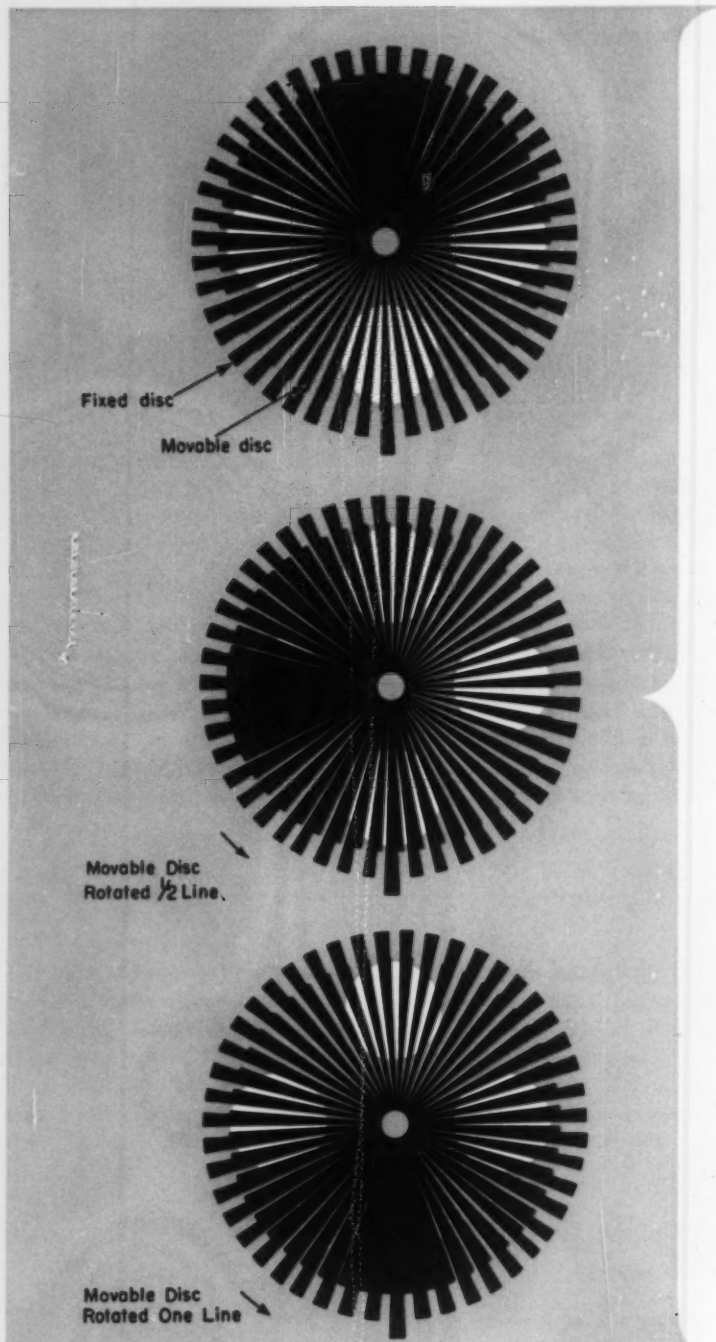




Angular cooling-fin construction assures effective heat transfer characteristics regardless of mounting position. In a "heat sink" designed for an electronic power supply, heat from the transistor section is dissipated by means of cooling fins mounted at a 45-degree angle on the front panel of the unit. The angular disposition of the cooling fins, developed by Allen B. DuMont Laboratories Inc., assures air flow between fins and a uniform heat-dissipation rate regardless of position of case.

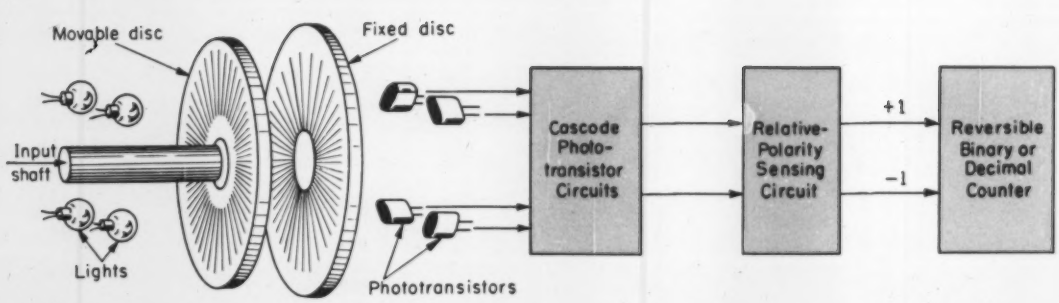
Centralized shoulder design for double thrust-bearing assemblies accommodates bidirectional loads and simplifies sealing problems under severe environmental conditions. In a design developed by Caterpillar Tractor Co. for a track roller-and-shaft assembly, two removable thrust bearings are fastened inside the roller, each in contact with one side of the central thrust collar on the shaft. Sealing requirements are simplified by this bearing-and-collar arrangement since thrust surfaces are enclosed and located as far as possible from source of contamination.





Optical gearing eliminates effects of friction and backlash in a system for precise measurement of shaft rotation. Input-shaft rotation is magnified for measurement purposes by means of two transparent discs having alternately opaque and clear sectors. One disc has one more opaque and transparent sector than the other, resulting in an interference pattern. One disc is fixed to the case and the other is mounted on the input shaft. Four lamps are located on one side of the discs, aligned with four photo transistors on the other side.

In operation, the lamps transmit light through the interfering disc patterns to the photo transistors which produce an electrical signal for speed indication. For a given relative orientation of the discs, no light will be transmitted in one region around the disc circumference. At 90 degrees either side of this region, the clear sectors will be half open; at 180 degrees the clear sectors will be aligned and completely open for maximum transmission of light. If the input shaft is rotated by an amount equal to one sector angle, the dark and light transmission regions rotate 180 degrees. A full rotation of the movable disc causes the dark and light patterns to perform rotations equal to the number of opaque lines on the rotating disc. The optical light pattern is thus "optically geared" to the input shaft with a magnification ratio equal to the number of lines. The Optisyn was developed by Components Div., Dynamics Research Corp.



Thermal Stresses in Design

Part 2—Quantitative Techniques for Brittle Materials

- Measurement of Thermal-Shock Parameters
- Short-Duration Thermal Shock

By S. S. MANSON
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ANALYTICAL aspects of thermal shock of brittle materials were discussed in the first installment of this series on thermal stress.[1] Failure criteria based on thermal shock parameters were also discussed. This second installment deals with the quantitative determination of the thermal-shock parameters by experimental means. Also outlined is the case when the duration of the shock is not sufficiently long to permit the maximum stress to be achieved. Here the conventional thermal-shock parameters cannot be used to rate materials.

Measurement of Thermal-Shock Parameters

Thermal shock resistance depends upon the two parameters (see Nomenclature):

$$P_1 = k\sigma_b/Ea$$

$$P_2 = \sigma_b/Ea$$

It follows that the conductivity is

$$k = P_1/P_2$$

and the nondimensional heat-transfer parameter is

$$\beta = ah/k = ahP_2/P_1$$

Also, the maximum nondimensional stress is

$$\sigma'_{max} = (1-\mu)\sigma_b/EaT_0 = (1-\mu)P_2 T_0$$

The thermal-shock resistance is obtained by substitution of these relationships into Equation 4 (Part 1):

$$T_0 = (1-\mu)\left[1.5\,P_2 + \frac{3.25\,P_1}{ah} - 0.5\,P_2\,e^{-\frac{16P_1}{ahP_2}}\right] \quad \text{.....(9)}$$

Thermal-shock resistance is the maximum sudden

Nomenclature

a	= Plate half-thickness
c	= Specific heat
E	= Elastic modulus
h	= Heat-transfer coefficient
k	= Conductivity
k_R	= Relative conductivity
P_1	= Thermal-shock parameter
P_2	= Thermal-shock parameter
T_0	= Initial uniform temperature of plate above ambient temperature (ambient temperature assumed to be zero)
t	= Time
α	= Coefficient of expansion
β	= Biot's modulus or nondimensional heat-transfer parameter
θ	= Nondimensional time
μ	= Poisson's ratio
ρ	= Density of material
σ'	= Nondimensional or reduced stress
σ_b	= Breaking stress
σ'_{max}	= Maximum nondimensional stress

[1]References are tabulated at end of article.

change in environment temperature T_0 that can be withstood without fracture by an infinite flat plate. Equation 9 shows that, if P_1 and P_2 are known, the thermal-shock resistance can be quantitatively determined.

Apparatus: The quantitative theory has been examined for validity by use of the ceramic steatite.[2] Several methods were used to determine the two thermal-shock parameters. Predictions based on these parameters were checked against the experimental thermal-shock resistance over a wide range of quench severities, that is, values of h. Fig. 10 shows the apparatus developed for this purpose. The specimens were circular discs insulated across the faces, and exposed to quench only at the edges, Fig. 10*a*.

After the discs were heated to arbitrary uniform temperature, the edges were quenched in an air stream, Fig. 10*b*, or in a water bath, Fig. 10c. For the mild quenches, the quench severity was varied by changing the air pressure within the nozzle manifold, resulting in varying heat-transfer coefficients. The water bath was used for severe quenches, particularly when the temperature was raised to the boiling point by the immersion heater. The heat-transfer coefficient for each setting of air pressure, and for the water quench, was determined from transient-temperature measurements in the disc.

Measurement of Physical Properties: The most direct approach toward the determination of the various parameters is to measure the individual values, k, σ_b, E, and a. This was done, and the agreement between the experimental value of thermal-shock resistance and the value predicted, on the basis of Equation 9, is shown in Fig. 11. Considering the scatter in data normally encountered in testing of brittle materials, this correlation is excellent. It should be pointed out that, since the test specimen was an edge-quenched circular disc instead of a face-quenched infinite flat plate for which the theory was derived, the applicable relation is that shown by Equation 9, with the term $(1 - \mu)$ removed.[2]

Although direct measurement of the physical properties entering into the thermal-shock parameters

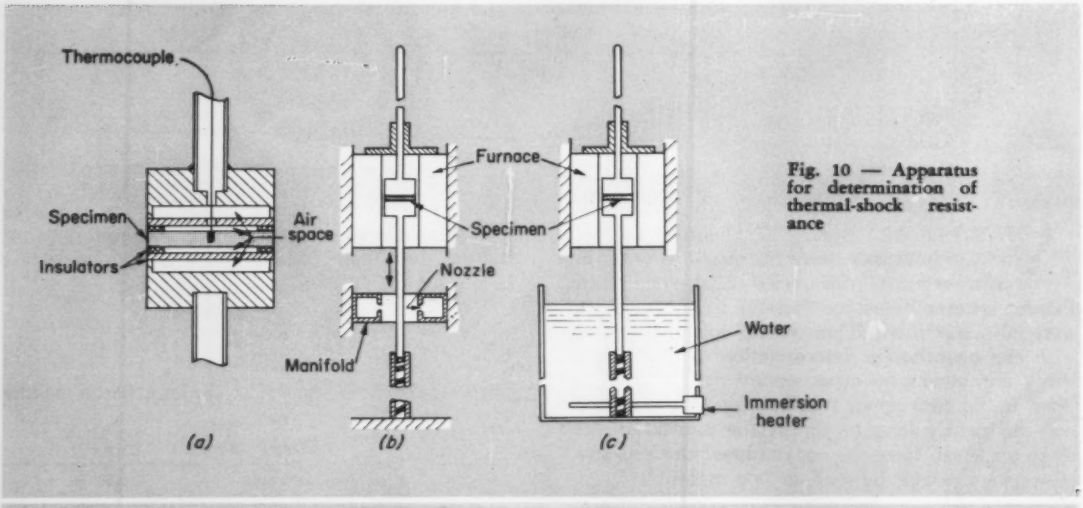


Fig. 10 — Apparatus for determination of thermal-shock resistance

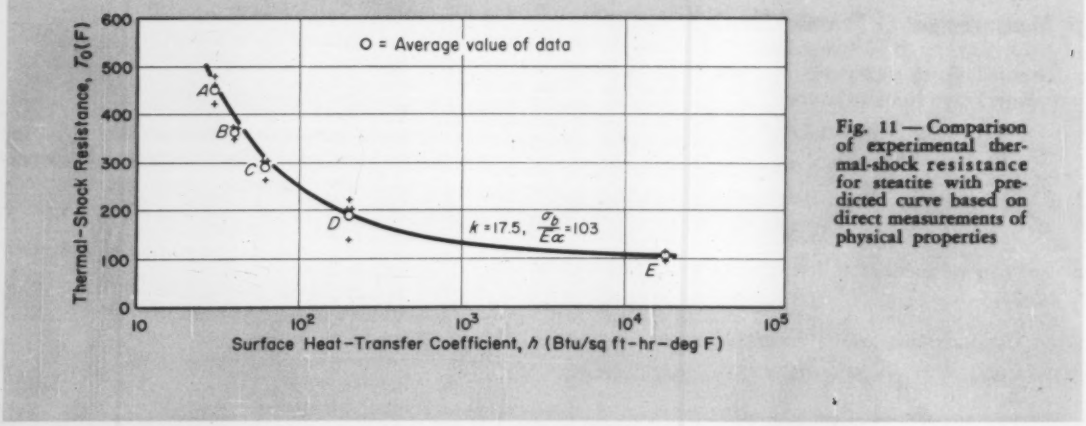


Fig. 11 — Comparison of experimental thermal-shock resistance for steatite with predicted curve based on direct measurements of physical properties

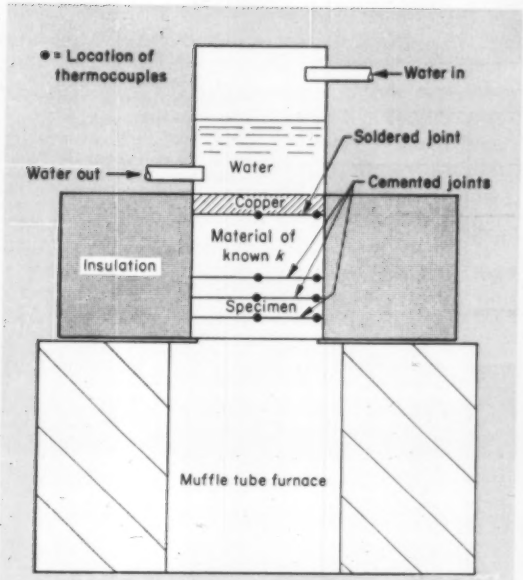


Fig. 12—Apparatus for rapid measurement of thermal conductivity

serves well to test the validity of the theory, this method requires a large amount of testing. This is especially true in brittle materials for which many duplicate test points are necessary to obtain reasonable average values.

Thermal-Shock Test and Conductivity Measurement: One other approach is to find the thermal-shock resistance for a known value of β and to measure the conductivity. From these data the thermal-shock parameters could be computed.

An apparatus, making direct use of the thermal-shock specimens, was devised for rapid measurement of thermal conductivity, Fig. 12. Heat is caused to flow vertically through a disc of known thermal conductivity and through a stack of three thermal-shock discs cemented together. The temperature drop across the reference material and across the center thermal-shock disc is measured. Since the heat flow across both discs is the same, the thermal conductivity of the test material can be determined. The conductivity becomes the ratio of temperature drop per inch thickness of the reference disc to that of the thermal-shock specimen, multiplied by the known thermal conductivity of the reference material.

Any convenient nozzle setting of the apparatus, Fig. 10*b*, could be used as a standard for determination of thermal-shock resistance under a reference condition, provided the heat-transfer coefficient is determined by prior calibration.[2] Substituting the measured value T_0 and the known value h into Equation 9, together with the relation $P_2 = kP_1$, permits solution of this equation by graphical methods. An alternate approach makes use of the graphical relation between σ' and β, instead of their relating formula.[2]

Fig. 13 shows the close agreement between the experimental thermal-shock resistance and that predicted on the basis of a single determination at point A, where h = 30 Btu per hr-sq ft-deg F, fracture temperature difference = 450 deg F, and measured conductivity k = 17.5 Btu-in./hr-sq ft-deg F.

Ideally, the determination of one of the thermal-shock parameters should be measured from the most severe quench obtainable. If β is large, the quench-temperature difference for fracture will not vary much, even over large variations of β. By Equation 9, this difference will be a direct measure

About the Author . . .

Well known for his contributions to the science of stress analysis, Mr. Manson couples his first-hand experience in research and engineering with an extensive knowledge of the literature in preparing this timely series on thermal stresses.

A graduate of Cooper Union Institute of Technology, he received his MS degree from the University of Michigan. Since joining the National Advisory Committee for Aeronautics in 1942, he has authored some 30 papers on many aspects of stresses and materials.

Mr. Manson is currently chief of the Materials and Structures Division of the Lewis Flight Propulsion Laboratory. He has held positions as head of the Stress and Vibration Section and chief of the Strength of Materials Branch in the NACA organization.

Continually active in NACA committee work, Mr. Manson has served on the Vibration and Flutter Subcommittee and is currently a member of the Powerplant Materials Subcommittee. He is also a member of the Joint ASTM-ASME Committee on the Effect of Temperature on Properties of Metals, and in 1956 was national president of the Society for Experimental Stress Analysis.

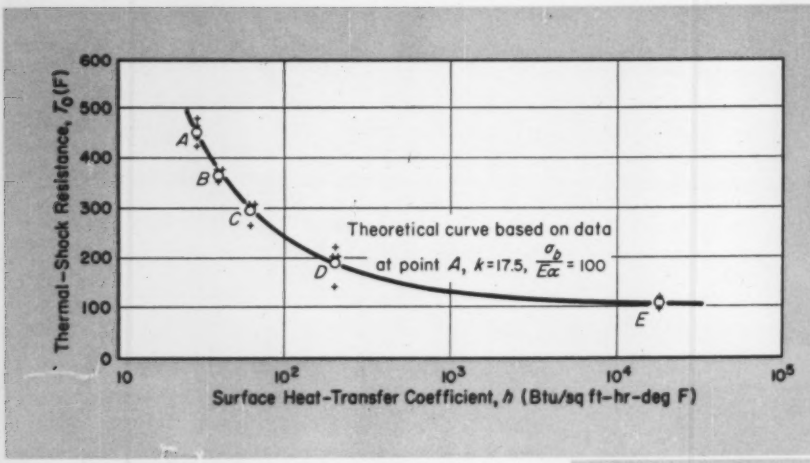
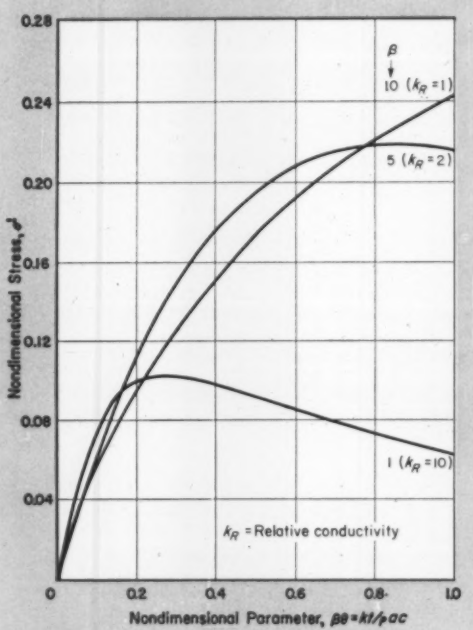


Fig. 13—Left—Comparison of experimental thermal-shock resistance for steatite with predicted curve based on one thermal-shock test and direct measurement of conductivity

Fig. 14 — Below — Stress at the center of plates which are identical except for different values of relative conductivity



of $P_2 = \sigma_b/Ea$. Hence, it would appear that a water quench would permit a method of measuring P_2. Unfortunately the heat-transfer coefficient between a hot solid and boiling water varies widely, as much as 100 to 1, depending on the temperature of the solid. The variation is a result of local boiling at the interface.

Therefore, some error could be expected when boiling water is used, particularly in quenching from high temperatures, Fig. 13.[2] However, in most cases it can be expected that if σ'_{max} associated with a water quench is assumed to be 0.90 instead of 1.0, then the resulting value of σ_b/Ea will be accurate to within about 10 per cent, which is generally considered close enough for most engineering purposes.

Short-Duration Thermal Shock

Thus far, only the maximum stress developed at the surface of the brittle plate has been discussed. Also, it has been assumed that the duration of the thermal shock is sufficiently long to allow the maximum stress to be developed. For quenching from a high temperature, the surface stress is tensile, and in general, failure occurs at the surface. However, with rapid surface heating rather than cooling, the surface stress is compressive and failure may not occur initially at the surface, but at the center of the plate where the largest tensile stress is developed.

Index of Merit Criterion: When the duration of the shock is not sufficient to allow the stress at the center of the plate to reach its peak value, the relative index of merit of materials depends on a different criterion than that already discussed. This short duration thermal-shock criterion can be most easily developed from an example.

Consider a series of materials which have similar geometry and identical physical properties, except for thermal conductivity. It is desired to determine the stress developed at the center of the plate in a given time for each of these materials.

CONDUCTIVITY: The conventional plot of σ' versus θ for given values of β as used in Fig. 4 does not serve the present purpose because both θ and β are functions of conductivity. Hence, an examination of this type of plot does not clearly reveal the significance of conductivity.

The type of plot that best demonstrates this point is shown in Fig. 14. Here the dimensionless stress σ' at the center of the plate is plotted against the product, $\beta\theta$. This product is also nondimensional, but since θ varies directly with conductivity and β inversely with conductivity, the product is independent of conductivity. Hence, for given values of h, ρ, a, and c assumed to be the same for all materials, the horizontal scale depends on time only. The different conductivities do, however, correspond to different values of β. Three conductivities are

shown, having relative values of 1, 2, and 10, or relative β values of 10, 5, and 1, respectively.

The higher the conductivity, the lower the peak value of stress. But in the range of low time, the curve for the material with the high conductivity lies above those with the lower conductivities. Hence, if the surrounding high-temperature medium is allowed to act on the surface for only a short time, the tensile stress at the center will reach a higher stress, the higher the conductivity.

HEATING TIME: The exact relative merit of the materials with different conductivities depends on the exact heating time. Thus, Fig. 14, time ranges can be determined for which each material is superior to the others, and time ranges can be found where each material is inferior to the others regardless of their conductivities.

It appears that, at least under certain conditions, good conductivity can be a detriment rather than an asset. A simple physical explanation for this phenomenon can readily be given. In the poor conductors, only the fibers very near the surface are affected by the applied heating for the first short interval of shock application. High stresses are induced in the surface, but these stresses are compressive and may not cause failure. The induced tensile stress at the center is low because the high compression of only a few fibers must be counteracted by the main bulk of the plate. For the better conductors, the effect of the surface heating is felt more rapidly throughout the plate. The compressive stress at the surface may be lower at a given time, but more fibers are under compressive stress, and the induced tensile stress at the center of the plate is higher.

No general formula has been found for the exact relative merit of materials with different conductivities. It depends upon the exact heating time. Obviously, a material with infinite conductivity would be the most desirable because no temperature gradient could be established, and no thermal stress developed.

▶ Summary on Brittle Materials

These first two articles have been concerned primarily with the thermal-shock behavior of brittle materials. It has been emphasized that the best measure of thermal-shock resistance is the determination of a temperature difference between specimen and quench medium that will cause failure in a single cycle. The specimen should be simple enough to permit accurate analysis, and the apparatus should be designed to force the heat path in the direction assumed in analysis. A method for quantitatively evaluating materials in thermal shock has been described and results were shown to be in good agreement with analysis. The stress value at which the material fractures in thermal shock must be determined from (1) a suitable thermal shock test, or (2) a bend test, in which the stress distribution developed during thermal shock is closely simulated. Use of conventional tensile strength data may yield erroneous results.

The approximate formulas developed for thermal-shock resistance involve both indexes now recognized in the literature, $k\sigma_b/Ea$ and σ_b/Ea. Neither index can, by itself, provide a basis for rating materials under all conditions of thermal shock. Corroborating analytical predictions, experiment has shown that the order of superiority of materials can be reversed by changing the severity of the thermal shock. It is important, therefore, to evaluate materials under conditions that simulate as closely as possible the shock severity of the intended application in order to avoid misleading results.

It should be emphasized that most of the analysis described refers to quenching a hot body into a cold medium, resulting in high tensile stresses in the surface fibers. Little quantitative research has been done on immersing a relatively cool body in a hot medium. Here, surface failure by spalling or fracture may precede development of tensile-fracture stresses in the body interior. Of importance are cases in which the duration of the shock is not long enough to permit the stress to reach its peak value. Then, it may be advantageous to use materials of low rather than high conductivity. Each requires a separate analysis of the type illustrated.

The next article in this series will discuss the effects of thermal cycling, material metallurgy, and temperature on thermal-stress fatigue of ductile materials.

REFERENCES

This article is the second in a series by S. S. Manson on thermal stresses in design. The previous article and the issue of MACHINE DESIGN in which it appeared are:

1. "Appraisal of Brittle Materials" ..... June 12, 1958

Another reference mentioned in the current article is:

2. S. S. Manson and R. W. Smith—"Quantitative Evaluation of Thermal Shock Resistance," *Trans. ASME*, Vol. 78, No. 3, April 1956, pp. 533-544.

Tips and Techniques

Checking Arcs

It is often convenient, when laying out work, to check the swing of circular arcs quickly without actually drawing the circles. This can easily be done using the right angle of a drawing triangle. First, lay down a diameter which can be either a drawn line or a length marked off on the edge of another triangle and slid into the desired position. Then, if the sides of the right angle are kept over the ends of the diameter while the triangle is rotated, its vertex describes the desired circle.—JESSE E. ROTH, *New York, N. Y.*

Do you have a helpful tip or technique for our other readers? You'll receive ten dollars or more for each published contribution. Send a short description plus drawings, tables, or photos to: Tips and Techniques Editor, MACHINE DESIGN, Penton Bldg., Cleveland 13, O.

How to apply

Drag-Link Mechanisms

in the synthesis of mechanisms

The drag-link or double-crank mechanism is a special case of the four-bar linkage. Constant input speed at one crank produces irregular output speed at the other crank.

In its own right, or in series with other mechanisms, the drag link is a versatile solution to many mechanism design problems. Offsetting its virtues, however, is one problem: Finding the linkage proportions that will give the desired input-output relationship.

Design aids developed in Germany, reported here in an original paper, go far in solving this problem. They open the way for easier exploitation of the drag link in new applications.

THE drag link is a four-bar linkage in which the shortest link is used as the fixed link and the two links mounted on the fixed link are able to rotate completely. For these conditions the so-called Grashoff rule has to be satisfied, according to which: 1. The shortest link of the four-bar linkage has to be the fixed link. 2. The sum of this shortest and the longest link has to be smaller than the sum of two other links. It is irrelevant which of the three moving links is the longest.

The drag link serves to transform uniformly rotating motions into irregularly rotating motions. For this reason it is well suited as a series mechanism with other mechanisms whose speed and acceleration conditions are to be transformed in a certain manner, in case a uniformly rotating driving link is present.

Speed and acceleration characteristics are directly related to the time displacement curves of the single links of the mechanism. If such a mechanism is to be constructed, in some cases it is sufficient for this reason to satisfy the displacement ratios and the angular ratios of the links of the mechanism. For higher demands, however, it becomes more important to be able to specify and also fulfill speeds and accelerations directly.

However, the state of the synthesis of mechanisms has not yet developed to a point where it is possible to exactly fulfill these demands. Until now one has, instead, in most cases restricted oneself to the first partial task. That is, one has only been able to specify angular and linear displacements in a mechanism. For this purpose, numerous procedures have been developed and also extensively used in practice. With the aid of the so-called valence-balance one can even predict how large the number of links in a mechanism has to be if one requests certain conditions; for instance, conditions concerning preciseness. In only a few cases has it so far been possible to specify also definite values of speed, force, torque, or even acceleration.

Another direction in the synthesis of mechanisms seems, however, to promise better prospects for the future. As long as simple mechanisms are concerned, one will be able to comprehend their characteristic values in curve families. This is easier the fewer paramaters (i.e., influencing values and therefore links) such a mechanism has. If it is also possible to introduce for the mechanism an evaluation index, one can not only read off of the

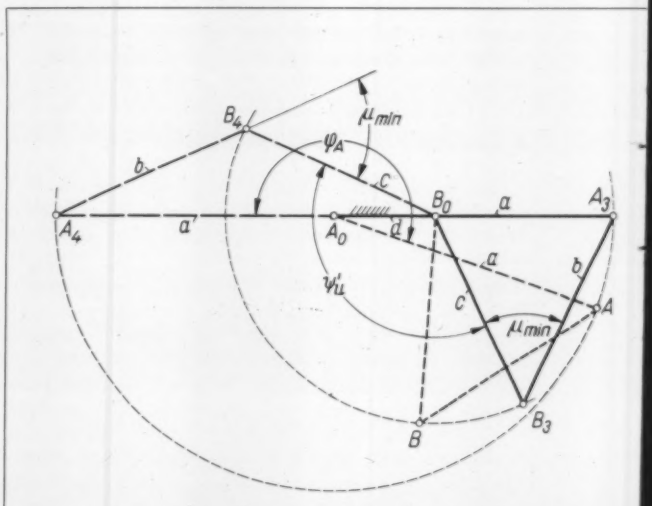


Fig. 1—Construction of a drag link with most favorable transmission

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curve families any desired mechanism, but also the one which is absolutely best for the purpose in mind.

One such characteristic value is, for example, the so-called transmission angle, which was originally introduced by Alt[1] to any important extent. The transmission angle indicates the quality of the motion transmitted by the mechanism. It is fortunate that one is able to express such an evaluation with only the aid of a simple angle. Recently, however, certain doubts have appeared concerning the application of the transmission angle. This is especially true in those cases in which dynamic forces as well as static forces act in the mechanism. Such objections are certainly justified. It will be necessary to evaluate these causes further and to work out new criteria of evaluation which, however, can no longer be expressed in such simple fashion. Generally, however, it has been shown that one can work

[1]References are tabulated at end of article.

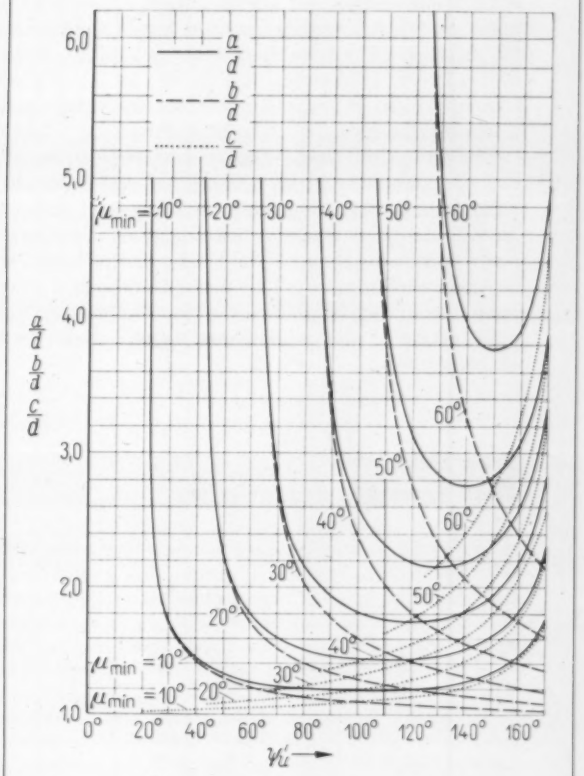

Fig. 2—Drag links with most favorable transmission

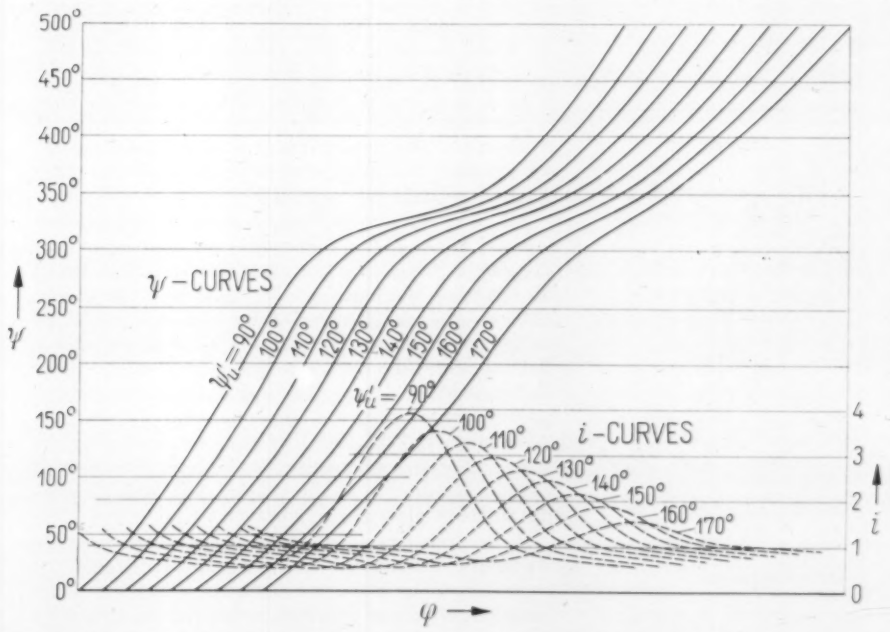

Fig. 3—Motion curves of drag links with $\mu_{min} = 40$ deg

relatively well for first approximations with the transmission angle. Its use is always recommended when slowly rotating mechanisms are involved. Or, for high-speed mechanisms, the possibility exists that such a mechanism has to be set in motion from a desired intermediate position in which case, also, only the static forces become active.

The drag-link mechanism has recently been described extensively in an elaborate scientific investigation. In the VDI research journal[2], several authors have undertaken extensive investigations simultaneously within the theme "The Production of Irregular Motions of Rotation." The methods described here have there been explained, so that here only the applications of the fundamentals given there need be considered.

Drag Links with Most Favorable Transmission

In Fig. 1 a drag-link mechanism is shown with driving crank *a*, coupler *b*, output link *c*, and fixed link *d*. If the drive of the mechanism proceeds from crank *a*, then the transmission angle is, according to Alt, the angle between coupler *b* and output link *c*. Transmission angle μ reaches its extreme value when crank *a* covers fixed link *d*. This happens twice during a rotation of the crank, and is demonstrated in Fig. 1 by the two positions of the mechanism $A_0A_4B_4B_0$ and $A_0A_3B_3B_0$. It is immaterial whether transmission angle μ shows itself as inner or outer angle between the two links *b* and *c*. Only the deviation of the transmission angle from 90 deg is important. If it has the value, $\mu = 90$ deg, then a transmission is given which is most favorable in this case. If, however, the angle $\mu = 0$ deg or 180 deg, then transmission of motion to the output link *c* is no longer possible.

The following discussion is based on the assumption that such a drag-link mechanism for specified dimensions behaves most favorably when the transmission-angle μ reaches the same values in its extremes—in position 4, as outer angle, and in position 3, as inner angle. Such drag-link mechanisms shall be called *drag links with most favorable transmission*.

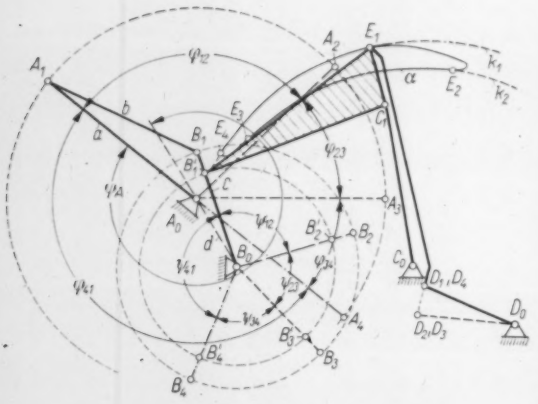

Fig. 4—Drag link as series mechanism for double-dwell mechanisms

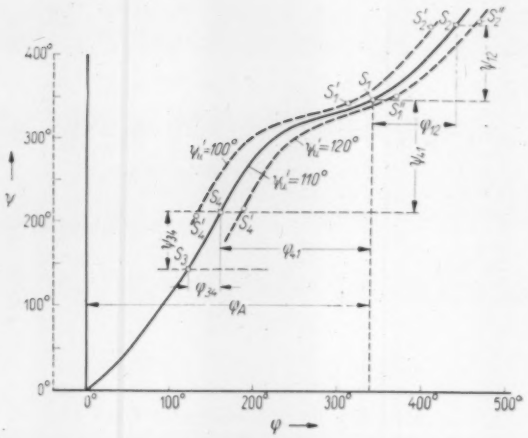

Fig. 5—Determination of the series mechanism for double-dwell mechanisms

One can construct such a mechanism if one starts with angle ψ_u', which is enclosed by the two positions of output link *c* in positions 3 and 4 of the mechanism. One begins with angle ψ_u' and marks off on both legs two equal lengths, $B_0B_4 = B_0B_3$. At point B_4 one constructs in the manner shown a given transmission angle μ_{min} on c, and at point B_3 one constructs the same angle μ_{min} on c again. Now one looks on the free legs of these added angles for point A_4 and A_3 with various, yet equal lengths *b*, until their connecting line goes through point B_0. Finally, one needs only to divide line A_3A_4 into halves and derive the fixed point A_0. A drag-link mechanism thus constructed is most favorable for transmission for the given angle ψ_u' and the given smallest transmission angle μ_{min}.

All drag links with most favorable transmission are plotted in Fig. 2 in terms of ψ_u' and μ_{min}. The diagram in Fig. 2 permits selecting the dimensions of all drag-link mechanisms with most favorable transmission. The solid curves show the ratio a/d, the long-dashed curves the ratio b/d, and the short-dashed curves the ratio c/d. It is appropriate to make the dimensions of the drag-link mechanisms dimensionless by relating the three moving links of the mechanism to fixed link *d*. Thus, one can enlarge or reduce all these mechanisms as desired. The laws of motion and angles at the driving link and the output link will always be the same.

A few remarks have to be made concerning the transmission-angle μ. The greater this angle, the more favorable is the transmission of motion. It is, however, of special importance that motion irregularity of output link *c* increases as the selected transmis-

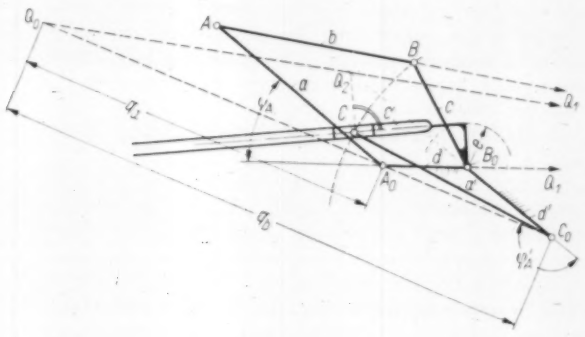

Fig. 6—Drag link connected in series with a slider crank

sion-angle μ_{min} decreases. However, the smaller the transmission-angle μ_{min}, the poorer is the quality of the transmission of motion. Thus, one is faced with the difficult problem of determining what transmission angle μ can still be used for the application in mind. Practical experiences have shown that for those mechanisms which rotate with relatively high speeds, a transmission angle of $\mu_{min} = 40$ deg is still tolerable. With slowly rotating mechanisms, it will not cause any difficulties to work with a transsion angle between 20 deg and 30 deg. In special cases, for which experimental investigations are recommended, however, it will be permissible to go even below these small values of the transmission angle.

Motion Diagrams of Most Favorable Drag Links

For angle $\psi_a' = 90$ deg to 170 deg the motion diagrams are plotted in Fig. 3 for the respective drag links with most favorable transmission. These are drag-link mechanisms in which in both covering positions of crank a with the fixed link d transmission angle μ_{min} has always the same value, $\mu_{min} = 40$ deg. For other values of angle μ_{min}, similar motion diagrams can be drawn. The ψ curves in Fig. 3 show the dependence of angle ψ, through which output link c passes, if driving link a performs uniform angular rotations. These latter angular rotations are plotted on the abscissa as values ϕ. The scale of the abscissa for the angle ϕ is the same as the one of the ordinate for the angle ψ. However no figures have been written on the axis of the abscissa, since the ψ curves have been drawn offset to each other in the direction of the abscissa. This way these curves do not cover each other and it is easier to work with them.

The curves of the transmission ratio of the drag link with most favorable transmission for $\mu_{min} = 40$ deg have also been plotted in Fig. 3. These i curves characterize the ratio between the speed of angular rotation ω_a of the drive link and the speed of angular rotation ω_c of the output link. The i curves always represent the differential curves of the ψ curves. The inflection points of the latter curves therefore have to correspond with a maximum or a minimum of the i curves. The following examples will demonstrate how the motion diagrams for drag links can be used for practical applications.

Drag Link as Series Mechanism for Two Dwells

In Fig. 4 a six-link dwell mechanism is shown, with driving crank B_0B_1', coupler $B_1'C_1$, and link C_0C_1. Coupler point E_1 of coupler $B_1'C_1$ describes coupler curve α, on which two circular arcs k_1 and k_2 with same radius $D_1E_1 = D_2E_2$ and centers D_1 and D_2 can be drawn. Output link D_0D_1 remains stationary, as has been known for dwell mechanisms for a long time, as long as these circular arcs coincide with coupler curve α. Thus the first dwell of the output lever D_0D_1 corresponds to a segment of the curve of the coupler from E_4 to E_1, while the second dwell of this lever corresponds to a segment of the coupler curve from E_2 to E_3. Angle ψ_{41} on the driving crank of the dwell drive B_0B_1', is assigned to the segment of the coupler curve E_4E_1, while angle ψ_{23} is assigned to the segment of the coupler curve E_2E_3.

It is known that for such coupler dwell mechanisms the driving angles of the crank are specified only within very limited ranges. With such mechanisms one must pay much more attention to obtaining as high quality a dwell as possible, by a good approximation of the circular arcs to the coupler curve, and furthermore to obtaining good transmission conditions in the total mechanism. However, one can change the angle of the driving crank if one connects a drag link in series with the dwell mechanism.

In the example in Fig. 4, crank a of the drag link connected in series is supposed to represent a uniformly rotating driving link. Crank c is therefore driven irregularly. It shall be required now that a driving angle $\phi_{41} = 180$ deg of crank a be assigned to angle ψ_{41} which is given by the dwell mechanism. Furthermore, it is requested that the start of the second dwell, which is characterized by angle ψ_{12} on crank c, is to be assigned to given angle ϕ_{12} on new driving crank a. The length of the second dwell, which is characterized by the angle ψ_{23} or ϕ_{23} shall for the time being not be specified.

The dimensions of a drag-link mechanism are now to be determined for the specifications listed. With the scales of Fig. 3 one plots on a rectangular coordinate system given angles ψ_{41} and ψ_{12} in the ordinate direction, while angles ϕ_{41} and ϕ_{12} are to be assigned in the abscissa direction. Thus one obtains points S_4, S_1, and S_2. If one has drawn these points on transparent paper, one must move this transparent paper always in such a way that the ordinates

and the abscissas remain parallel to the ones in Fig. 3. This way one tries to have points S_4 and S_1 cover one of the ψ curves. One finds according to the indications in Fig. 5, for instance, for the curves $\psi_u' = 100$ deg and $\psi_u' = 120$ deg that points S_2' and S_2'' do not remain on the curve. However, they meet in the case of the curve $\psi_u' = 110$ deg, so that the drag-link mechanism that corresponds with this curve fulfills the requirements. If one adds here an angle ψ_{34} in the direction of the ordinate, point S_3 results immediately and with it the driving angle ϕ_{34}, which crank a passes through when the second dwell of the output lever D_0D_1 begins.

If one has on hand several motion diagrams like the one in Fig. 3 (that is, for other angles μ_{min}) one can try to have the fourth point S_3 also cover a corresponding curve, in case this is so specified. This means that it is possible to bring both dwells of a six-link dwell mechanism into any desired relationship with the specified crank angles, if one connects a drag link in series.

If one considers as reference position in Fig. 5 the position of the original dwell mechanism which corresponds with point 1, one can, up to the start of the curve which fulfills the requirements $\psi_u' = 110$ deg, read off an angle ϕ_A on the corresponding abscissa scale. This angle characterizes, in the reference position of the mechanism, the position of crank a from the covering position with fixed link d of the drag-link mechanism. For all drag-link mechanisms which fulfill the motion diagrams of Fig. 3 it is assumed that their motion begins when crank a lies on the extension of fixed link d.

According to Fig. 5, therefore, a drag-link mechanism with angle $\psi_u' = 110$ deg and transmission angle $\mu_{min} = 40$ deg fulfills the specifications of the mechanism in Fig. 4. With these two characteristic values one can immediately read off in Fig. 2 the dimensions of the corresponding drag link as follows: $a/d = 2.33$, $b/d = 2.04$, and $e/d = 1.48$.

If now in Fig. 4 pivot A_0 of driving crank a is given in relation to pivot B_0 of the crank, then the length of the fixed link is given by distance $A_0B_0 = d$, and one can calculate from the foregoing values the absolute dimensions for crank a, coupler b, and driving crank c of the drag link connected in series. In the reference position which, for instance, corresponds with coupler point E_1, the beginning angle ϕ_A, which is read off Fig. 5, has to be entered. With the calculated dimensions of the drag link, one can draw it as in Fig. 4 in reference position 1 and combine it rigidly in suitable manner with driving crank c of the six-link dwell mechanism.

Irregular Rotation with Temporarily Constant Angular Speed

As can be seen from the motion diagrams for the simple drag link, the angular velocity of link c always fluctuates between a maximum value and a minimum value with constant angular speed of the driving link. With the aid of a simple drag-link mechanism it is not possible to satisfy the specification that requires that the output link temporarily have a constant angular speed during an irregular motion of the output link. For this purpose one has to use a mechanism with six links. In the following example a drag link is connected in series with a rotating slider crank.

A six-link mechanism, consisting of a drag link and a rotating slider crank is shown in Fig. 6. If, according to the specifications, driving crank a shall rotate uniformly, and if output link a' of the whole mechanism shall temporarily rotate uniformly too, then a certain transmission ratio is given as the ratio of the two angular speeds of links a and a'. This transmission ratio can also be expressed geometrically.[3] One needs then only to determine the instant center Q_0 of links a and a'. At first one determines the instant center Q_1 as the intersecting point between coupler b and fixed link d of the drag link. Instant center Q_2 of the rotating slider crank connected in series results if at point C of crank a' one draws the perpendicular to the slot and extends this line to intersect with fixed link d' of the rotating slider crank. Now one only needs to intersect straight line Q_1Q_2 with straight line A_0C_0 to derive the desired instant center Q_0. The distance of instant center Q_0 from pivots A_0 and C_0 results directly in the transmission ratio:

$$i_0 = \frac{\omega_a}{\omega_{a'}} = \frac{q_b}{q_a}$$

where ω_a = angular speed of crank a, $\omega_{a'}$ = angular speed of output link a', and q_a and q_b = distances between instant center Q_0 and pivots A_0 and C_0.

Total transmission ratio of the mechanism is also equal to the product of the individual transmission ratios, as is known already from gear mechanisms. If, for instance, i_1 is the momentary transmission

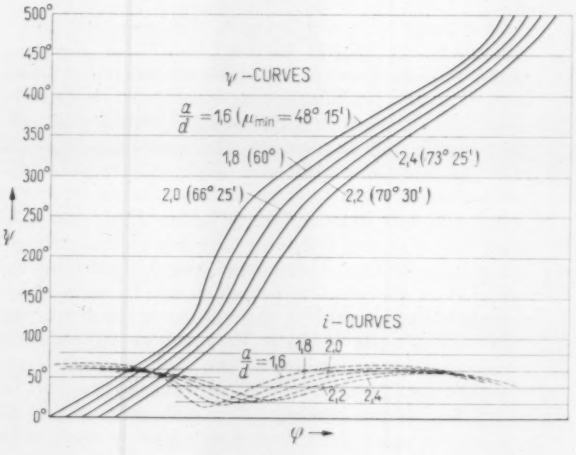

Fig. 7—Motion curves of rotating slider cranks

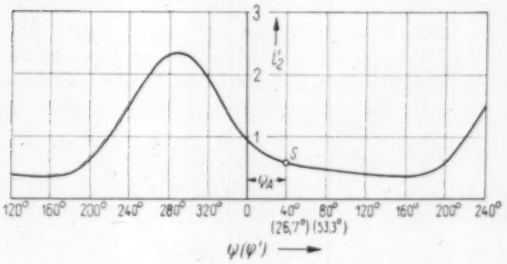

Fig. 8—Reduced transmission ratio of a drag link

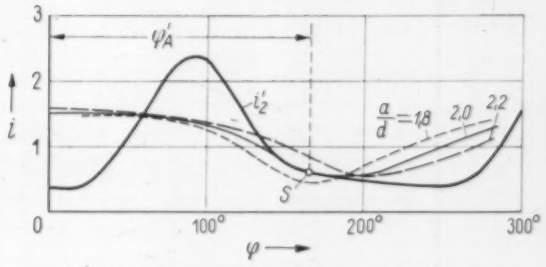

Fig. 9—Total transmission ratio of drag link and slider crank

ratio of the drag link, and i_2 the momentary transmission ratio of the slider crank connected in series, then $i_0 = i_1 i_2$.

If one has two mechanisms of known transmission ratio patterns, it must be possible to satisfy, with more or less good approximation, a resulting transmission ratio i_0 by using suitable procedures. At first one begins with a given drag link, for instance, the one with the characteristic values $\psi_u' = 100$ deg and $\mu_{min} = 40$ deg. It is furthermore assumed that the motion diagrams of a few rotating slider cranks are known according to Fig. 7. Here also are entered the uniformly varying angles ϕ of driving crank a as values on the abscissa. The values ψ of the ordinate show then the variation of angle ψ of lever c of the slider crank. The i curves again show the transmission ratio as the ratio between the angular speed of driving crank a and the angular speed of output link c. According to the scheme of the mechanism in Fig. 6, however, for the slider crank link c' is the driving link, and crank a' the output link. If transmission ratio i_2 holds for the diagram of Fig. 7, then, on the other hand, the reciprocal value of this transmission ratio holds for the arrangement according to Fig. 6. If one calls this i_2', then $i_2' = 1/i_2$.

Therefore, the formula for the total transmission ratio has to be $i_0 = i_1(1/i_2')$. And from it, $i_2' = i_1/i_0$.

The variation of the transmission ratio for the assumed drag link with $\psi_u' = 100$ deg and $\mu_{min} = 40$ deg is known. According to the foregoing equations, it is the value i_1. From this one can calculate the value i_2' for any desired intermediate position, and one obtains thus a so-called reduced curve of the transmission ratio of the drag link mentioned. This curve is plotted in Fig. 8. Notice that the scale of the abscissa in Fig. 8 is to be changed in comparison with the diagrams in Fig. 3 by the transmission ratio i_0. For temporarily uniform transmission of motion, which is required in this problem, the angles themselves at the driving link and the output link have to be converted according to the transmission ratio i_0.

One tries to cover the curve i_2' of Fig. 8 with one of the i curves of Fig. 7 to as great an extent as possible. Then the required transmission ratio i_0 of the total mechanism according to Fig. 6 is satisfied. A good correspondence between two i curves is found according to Fig. 9 with the curve $a/d = 2.0$. Here it must be noticed that a translocation for the transmission ratios can only be done in the direction of the abscissa. The total motion diagram of Fig. 7 is valid for a value $e/d = 0.4$, i.e., slider cranks which satisfy these curves have an eccentricity e, whose ratio to fixed link d is 0.4.

Diagrams for the rotating slider cranks in Fig. 7 begin in a position of the mechanism corresponding to that in which crank a covers the extension of fixed link d. One then chooses in Fig. 9 a point within the approximate coincidence of both curves as reference point S for the total position of the mechanism. This point S is located away from the beginning of the $a/d = 2.0$ curve by the abscissa value ϕ_A'. Angle ϕ_A' is to be added to the position of fixed link $d' = B_0C_0$ in Fig. 6. The same point S in Fig. 9 corresponds to a point S in Fig. 8 and here also with beginning angle ϕ_A of crank a of the primary mechanism, the drag link. Crank a of the drag link has to be arranged in relation to fixed link d in the reference position under this angle ϕ_A. Dimensions for the drag link mechanism are read off Fig. 2 for the values $\psi_u' = 100$ deg and $\mu_{min} = 40$ deg. Thus, all the dimensions of the six-link mechanism in Fig. 6 are determined.

Fig. 10 shows for the mechanism in Fig. 6 the actual variation of the transmission ratio i_0. One can see that for angles from $\phi = 0$ deg to about 80 deg a relatively good constancy of the transmission ratio i_0 is present. In addition, the curve of the transmission ratio has also a maximum and a minimum value.

Most Favorable Transmission with Optimum Angular Ratios

From the motion diagrams of Fig. 3 again, the most favorable drag links which guarantee best transmission for certain angular ratios can be read off. It is very often desired to transform a uniformly rotating motion into an irregularly rotating motion in such a way that a certain angle ψ of the driving link corresponds with as large or as small as possible an angle of the output link. In the following examples related applications will be shown.

Fig. 11 shows for the given problem the most suit-

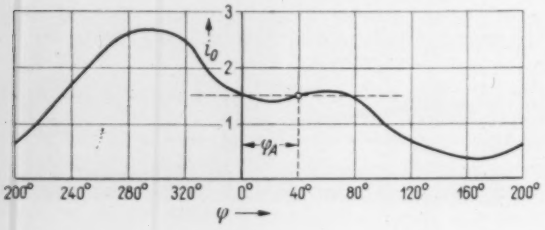

Fig. 10—Variation of the transmission ratio of drag link and slider crank

able drag link mechanisms for an angle $\mu_{min} = 40$ deg. If, for instance, for a certain angle ϕ_x of the driving link a certain angle ψ_x of the secondary link on the drag link is to be derived, then one finds the corresponding value ϕ_x of the abscissa and the given value ψ_x of the ordinate. Their intersection in the curve family marks the proper drag link. For this again the characteristic values ψ_u' of Fig. 2 are relevant. The dashed curves show the angle ϕ_A, which is enclosed by driving crank a of the drag link and fixed link d. In the position of the mechanism as characterized by the angle ϕ_A the given angle ϕ_x begins. Concerning the derivation of the diagrams of Fig. 11, no further details need to be mentioned here since they have been covered elsewhere.[2]

Use of the curve families of Fig. 11 may be demonstrated with an example. It is required that at driving link a of a drag link an angle $\phi_x = 180$ deg is to be passed through. At output link c an angle $\psi_x = 100$ deg is to correspond to this value of ϕ_x. The abscissa value of 180 deg and the ordinate value of 100 deg intersect on the curve at about $\psi_u' = 120$ deg. With the characteristic values $\psi_u' = 120$ deg and $\mu_{min} = 40$ deg (the total curve family in Fig. 11 is valid for $\mu_{min} = 40$ deg) one can again determine in Fig. 2 the dimensions of the corresponding drag link. If one goes on the ordinate $\phi_x = 180$ deg up to the dashed curve with the parameter $\psi_u' = 120$ deg, there results a starting angle of $\phi_A = 214$ deg, which is enclosed by crank a in the starting position and fixed link d.

The diagrams of Fig. 11 show also the limits within which one can produce transformations of angles with the aid of a simple drag link. If, for instance, the problem is to arrange for a drive angle of $\phi_x = 180$ deg and an output angle of $\psi_x = 30$ deg, one will find that the intersection of the two ordinates will not fall within the area of the curves of this diagram. Thus, for this problem, there does not exist a drag link with the smallest transmission angle $\mu_{min} = 40$ deg. Similar new curve families are planned for all values of μ_{min} which fall within the limits of practical usefulness. It is to be suspected that for the given figures a practically useful drag link can then be found.

If one, however, connects two drag links in series, one can derive a useful mechanism without difficulties. One can, for instance, select a first drag

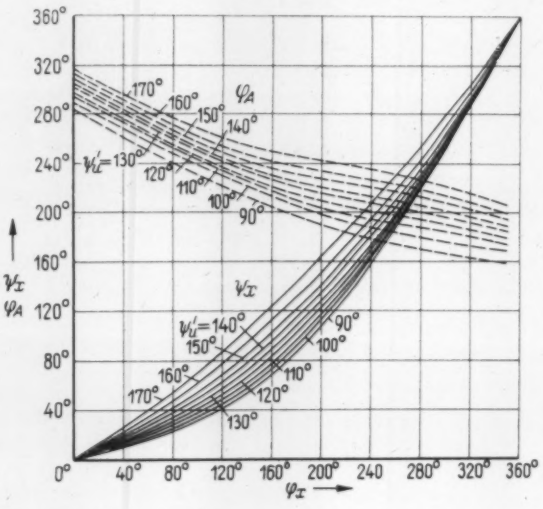

Fig. 11—Optimum assignment of angles of drag links

link for an angle $\phi_x = 180$ deg and an intermediate angle $\psi_x = 90$ deg. For this, one obtains the parameter $\psi_u' = 100$ deg (see Fig. 11). The output angle ψ_x of the first drag link is, however, equal to the drive angle ϕ_x' of the second drag link. Thus if one enters this angle $\phi_x' = 90$ deg the final output angle $\psi_x' = 30$ deg into the diagram of Fig. 11, one obtains again as a parameter the angle $\psi_u' = 100$ deg. Since for both drag links the parameter $\psi_u' = 100$ deg was found or could be selected, two drag links are present with the same dimensions, which is of great importance for practical production. If one goes further up for the value $\phi_x = 180$ deg and $\phi_x' = 90$ deg until one reaches the dashed curves with the corresponding parameter $\psi_u' = 100$ deg, one obtains the starting angles $\phi_A = 206$ deg and $\phi_A' = 244$ deg.

The two drag-link mechanisms connected in series are drawn in Fig. 12 in the two positions 1 and 2. All other characteristic values can also be read off the figure. The dimensions of these drag links are again, as in the previous examples, read off the diagrams of Fig. 2 with the characteristic values $\psi_u' = 100$ deg and $\mu_{min} = 40$ deg. As soon as the lengths of the fixed links $A_0B_0 = d$ and $A_0'B_0' = d'$ are determined, the dimensions of the moving links for both drag links can be calculated without difficulty, as outlined in the foregoing examples.

Modified Genevas with Drag Link in Series

It is known that one can change in any desirable manner the index ratio of a Geneva mechanism by connecting a drag link as a primary mechanism.

Index ratio means here the ratio of the periods for stop and motion of the driven gear. The present investigation is intended to show that one can not only determine any desired primary mechanism, but also the most favorable one.

A four slot Geneva mechanism according to Fig. 13 can guarantee for the output gear only an indexing angle $\psi_x = 90$ deg. If it is, however, required that for each index period an angle of $\phi_x = 180$ deg has to be passed through, one can connect a drag link. The most favorable drag link for this given angular ratio of 180/90 can be read off Fig. 11, if one chooses 180 deg on the abscissa and 90 deg on the ordinate. A characteristic value $\psi_u' = 100$ deg results which one can use in connection with the other characteristic value $\mu_{min} = 40$ deg to determine in Fig. 2 the dimensions of the drag link. In Fig. 11, one obtains a starting angle of $\phi_A = 205$ deg at the intersection of $\phi_x = 180$ deg and $\psi_u' = 100$ deg. This angle marks the reference position of the drag link in Fig. 13 after fixed link A_0B_0 has been determined.

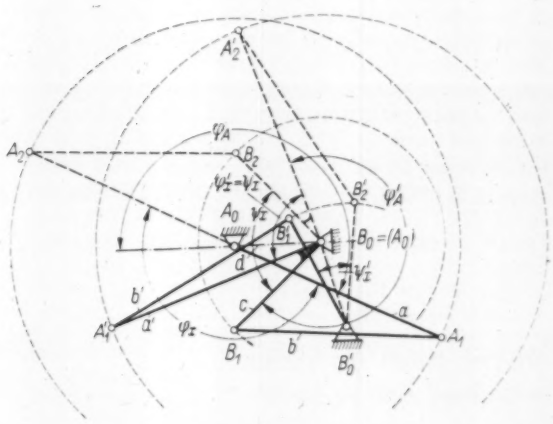

Fig. 12—Two drag links connected in series

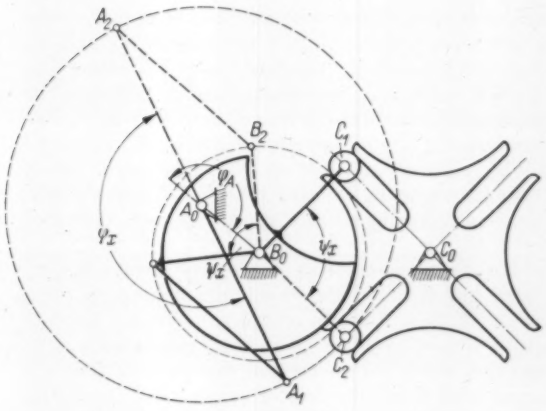

Fig. 13—Geneva mechanism with drag link connected in series

Oscillating Motion with Fast Advance and Slow Return

If a link of a mechanism has to be moved from a uniformly rotating driving crank, such that it oscillates back and forth and uses a much larger or smaller crank angle for the advance than for the return, one will try to apply the four-bar linkage in this case also. For the evaluation of the most favorable mechanism for this problem, it is useful to apply the transmission angle as defined by Alt.[1] This angle is the basis of the drag links with most favorable transmission that are dealt with here.

A four-bar linkage is called a crank and rocker if a driving crank (a') rotates completely and an output link (c') only oscillates. Such a crank and rocker mechanism is shown in Fig. 14. If crank a' is turned from position B_0B_1' to position B_0B_2' by angle ϕ_0, which deviates considerably from 180 deg, then lever c' has moved from position C_0C_1 into position C_0C_2 by angle ψ_0. If crank a' keeps turning in the same direction until it has gone through a full turn, lever c' is turned back again by the angle ψ_0. Therefore, lever c' uses for the advance a larger crank angle than for the return. If crank a' rotates uniformly, this means that lever c' is moved slowly in one direction but runs faster in the opposite direction.

Investigations concerning the most favorable transmission angle of such crank and rocker mechanisms have been undertaken by Alt and Volmer.[3, 4] The

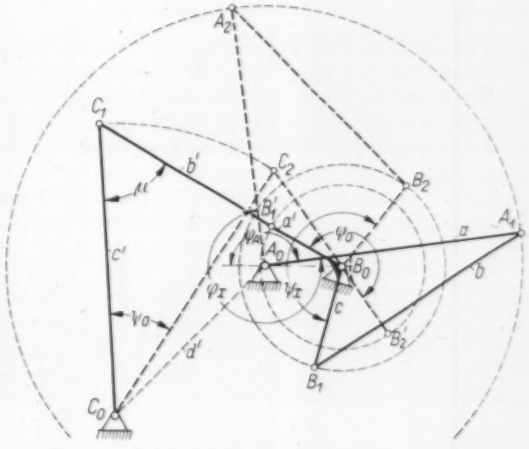

Fig. 14—Two four-bar linkages for oscillating motion with fast advance and slow return

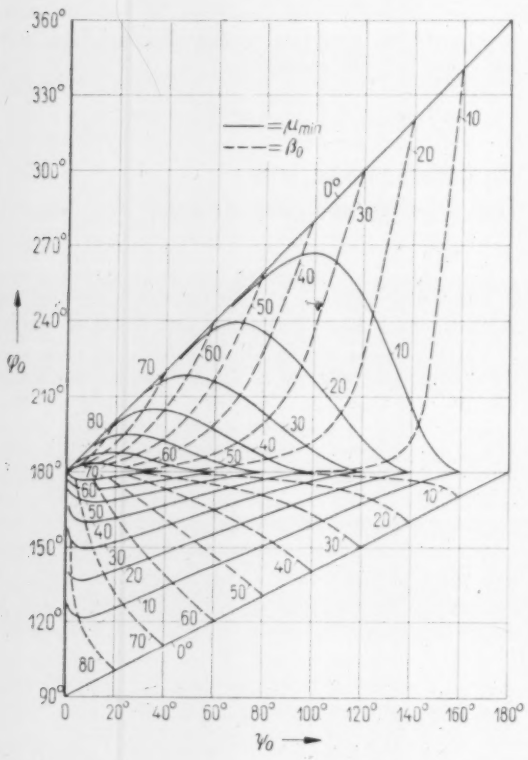

Fig. 15 — Crank and rocker mechanisms most favorable for transmission according to Volmer

diagram in Fig. 15 has been derived from these investigations. From it one can read off immediately the most favorable mechanism with respect to transmission angle μ_{min}, if a crank angle ϕ_0 and an oscillating angle ψ_0 are given. In the example in Fig. 14, it is required that angle $\phi_0 = 205$ deg and angle $\psi_0 = 36$ deg. If one goes with these ordinate values into the diagram in Fig. 15, one obtains for the most favorable transmission angle μ a value of 40 deg. Also, there results on the dashed curve an angle $\beta = 64$ deg 30 min. This angle is a characteristic value which is being used for further curve families according to Volmer. The dimensions of this most favorable four-bar linkage used as a crank and rocker can be read off other curve families. These values are contained in the original papers by Alt and Volmer.

The curve family, Fig. 15, shows that, for the angle $\mu_{min} = 40$ deg, no greater difference can be obtained for the differential advance and return of the crank and rocker mechanism. If one wants to specify still greater differences for the times of advance and return of output lever c', it is also in this case recommended that one connect another drag link in series with the four-bar linkage which works as a crank and rocker. For instance, it may be required that at new driving link a an angle $\phi_x = 270$ deg is to be passed through while output link c of the drag link passes through an angle $\psi_x = \phi_0 = 205$ deg. It is clear that the drag link connected in series has the same most favorable transmission value as the crank and rocker, if it has the same transmission angle μ_{min}. In Fig. 11 which, as already mentioned, holds for a transmission angle $\mu_{min} = 40$ deg, one has to coordinate an abscissa value of $\phi_x = 270$ deg and an ordinate value of $\psi_x = 205$ deg. Both ordinates intersect on a curve with the parameter $\psi_u' = 90$ deg. This means that the given conditions are satisfied by a drag link, with properties most suitable for transmission, having the parameters $\psi_u' = 90$ deg and $\mu_{min} = 40$ deg. With these two values, one can again determine in Fig. 2 the dimensions of the corresponding drag link. For the abscissa $\phi_x = 270$ deg one obtains for the parameter $\psi_u' = 90$ deg on the dashed curve a starting angle ϕ_A, which is drawn in Fig. 14 and which marks the starting position of crank a in relation to fixed link d.

With respect to the curve family in Fig. 11, if one can not obtain useful values with the angles ϕ_x and ψ_x, one then can still calculate with the complementary angle to 360 deg. For instance, for the mechanism in Fig. 14, the problem would have been the same, if instead of the angles ϕ_0, ϕ_x, and ψ_x, their complementary angles to 360 deg had been prescribed, i.e., if $\phi_x = 90$ deg and $\psi_x = 155$ deg. One would not have been able to find a useful drag-link mechanism for these values in Fig. 11. However, for the complementary angles the same results already determined would have been obtained.

Six-Link Dwell Mechanism with Drag Link in Series

There exist six-link mechanisms in which a driving link can rotate with constant angular speed, and in which an output link also rotates, where this latter motion, however, is interrupted by a dwell. Such a six-link rotary dwell mechanism thus corresponds with an indexing mechanism similar to the Geneva mechanism. Such a mechanism is shown in Fig. 16. It is called a six-link two-pivot mechanism, because it has only two fixed pivots B_0 and C_0. The mechanism consists of rotating input link B_0B', output link C_0CC' and intermediate links FC, GC', and GFB'. While link B_0B' of the mechanism passes through angle ψ_x, output link C_0CC' stands still. The condition for such a dwell has been described earlier.[5]

For the demonstration of a rotary dwell one considers link C_0CC' of the mechanism stationary. Then point B' describes the coupler curve α. Coupler curve α can be fitted with good approximation by circular arc k. The center of this circle is then the fixed point B_0 of the driving crank B_0B'. To obtain a complete rotation of the driving link and the output link of the six-link two-pivot mechanism, coupler curve α has to be shaped in such a way that on the one side of the circle k the curvature becomes greater, while on the other side of the circle k the

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The *Transactions* also include an extensive paper by Mr. Hain on mechanism developments reported in the German language since 1945. This paper will not be published elsewhere.

The Fifth Conference on Mechanisms will be held at Purdue University, Lafayette, Ind., October 13 and 14, 1958.

curvature becomes smaller. Unfortunately a dwell angle ψ_x not any greater than 90 to 100 deg can be obtained with such a six-link two-pivot mechanism.

It is, therefore, here also recommended, if a greater dwell angle is required, that a drag link be connected in series. In Fig. 16 angle $\psi_x = 72$ deg. It is the output angle of the drag link to be connected in series. If a driving angle $\phi_x = 180$ deg is required (that is, if the index ratio of the total mechanism is supposed to be 1/1), one finds in Fig. 11 for the two ordinates $\phi_x = 180$ deg and $\psi_x = 72$ deg an intersecting point which is located outside the curves. This means that there does not exist a drag link with a transmission angle $\mu_{min} = 40$ deg for the posed problem. However, one can find a mechanism for $\mu_{min} = 30$ deg. The curve families for this angle have a shape similar to those in Fig. 11; therefore, they have not been drawn. In any event, as in the previous examples, the characteristic values result for the proposed drag link. It has, in Fig. 16, driving crank a, coupler b, and output link c. The latter is rigidly connected with driving link B_0B' of the six-link two-pivot mechanism.

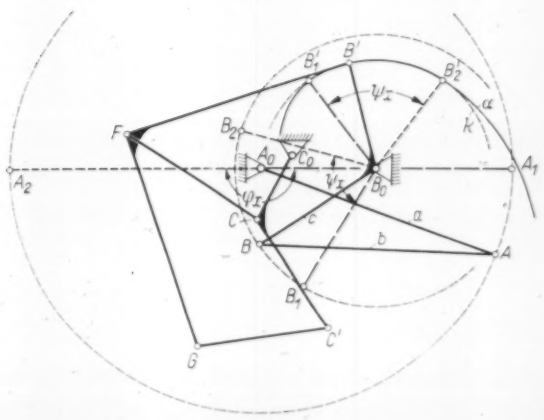

Fig. 16—Rotary dwell mechanism with drag link

Summary

The examples shown are intended to demonstrate with what advantages the four-bar linkage can be used as a drag link mechanism. There have been mentioned three fundamentally differing possibilities of application:

1. Utilization of the time-displacement diagram of the drag link with most favorable transmission.
2. Application of the diagrams for the transmission ratio of the drag link with most favorable transmission.
3. Utilization of diagrams for drag links, which give for specified transformation of angles the mechanisms with most favorable transmission.

As mentioned repeatedly in this article, diagrams for other transmission angles μ_{min} are still in process. These diagrams will later be published as work sheets for the designer.

Obviously, such diagrams cost originally much work and trouble. However, once they are on hand, they represent a valuable aid for the design of mechanisms. They save the designer of mechanisms time-consuming design effort. Besides, if he tries to construct such drag-link mechanisms himself, he never knows if he has really found the one with most favorable transmission. The value of the curve families that are in preparation lies, therefore, not only in the fact that they are easy to use, but that they also give certainty that one has not just chosen any possible drag-link mechanism, but the absolutely best one that can possibly exist.

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Applied Design of Mechanisms

They Say . . .

"A patent is nothing more than a grant by the United States to an inventor of the exclusive right to exclude others from using his invention for a period of 17 years. In exchange for this the inventor publishes a working description of his invention in the patent, so that when the 17 years have expired anyone can read the patent and, using its teaching, practice the invention."—C. W. OOMS, *patent counsel, La Salle Steel Co., Hammond, Ind.*

A Designer's Guide to the

ELECTRONIC-MACHINING

By **FRANK TWITCHELL and J. R. ZIMMERMAN**
Producibility Design Engineers
Northrop Aircraft Inc.
Hawthorne, Calif.

THERE are two methods of electronic machining in use today—ultrasonic-impact and electrical-discharge machining. With these processes, drilling, boring, slicing, or grinding of the hardest and most brittle materials is accomplished quickly and accurately. Parts that are difficult to produce by conventional methods are made regularly in the aviation, electronics, and some other industries with spectacular savings in time and labor.

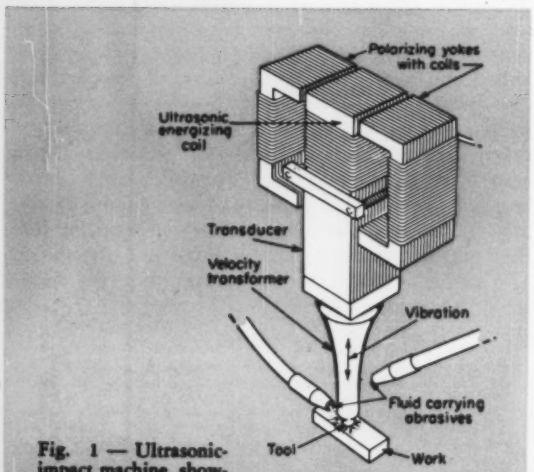
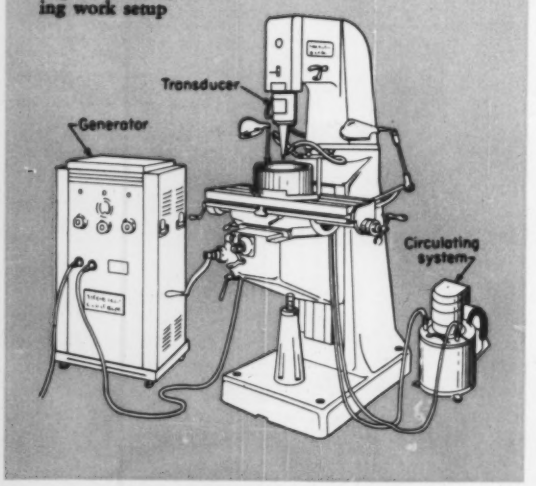


Fig. 1 — Ultrasonic-impact machine, showing work setup



▶ Ultrasonic-impact machining

The equipment, Fig. 1, consists of an electric generator with oscillator and amplifier, a transducer for mounting on the tool holder of a suitable machine tool, and a circulating system for a liquid holding abrasive particles in suspension. The tool, shaped to the desired configuration, is mounted on the transducer, which causes it to vibrate perpendicular to the work surface. As a continuous flow of liquid is supplied between tool and work surface, vibratory movement of the tool causes abrasive particles suspended in the liquid to bombard the work, producing metal removal over an area that duplicates the shape of the tool.

Although the abrasive particles strike the work with impact forces up to 150,000 times their own weight, cutting forces seldom exceed 10 lb. This small force, occurring 25,000 times per second, results in fairly rapid stock removal but the absence of direct contact between tool and work, plus the presence of the coolant, does not cause a rise in the material temperature. Therefore, impact machining is a "cold cutting" process which does not produce stresses or alter the physical structure of the workpiece. Material-removal rate depends principally on type of abrasive used and amplitude of the vibrations. A cutting speed of 0.004 ipm can be obtained at 25,000 cps using tools of small cutting-face area. This rate drops to 0.0006 ipm with tools of large cutting-face areas.

Cutting tools can be mild steel or brass. The abrasive grit wears away both tool and workpiece; however, tool wear is confined to the bottom face where the dimensions are generally not critical. Since there is no lateral cutting action, the profile of the tool remains unchanged. For fine profiles or

PROCESSES *for intricate holes and contours in nonmachinable materials*

high precision, a finish cut with finer abrasive usually follows the initial roughing operation.

Applications: Hard materials such as carbides, hardened tool steel, and high-hardness alloys are easily machined. Materials cut may be either conductors or nonconductors. Extreme hardness of the material is not a limiting factor. Nonmetallics, such as glass, ceramics, quartz, and other minerals, can also be machined.

Complex shapes which would be impractical or impossible to make by conventional methods can be readily produced in these materials, Fig. 2. Tolerances of ±0.0005 in. are not uncommon, although the usual roughing-cut tolerance is from ±0.001 to ±0.0015 in. A surface smoothness of 32 mu in. rms is readily obtained, with 8 mu in. rms possible under very favorable conditions.

▶ Electrical-discharge machining

Another form of electronic machining uses an intermittent high-frequency spark to erode the material. Unlike ultrasonic machining, the work must be an electrical conductor. The workpiece is connected to the positive terminal of a power supply and the tool, acting as an electrode, is connected to the negative terminal. The workpiece is usually submerged in a dielectric coolant, Fig. 3, and the metal is eroded by arcing across a minute gap between tool and work. There are three processes utilizing electric discharge for machining:

1. Contact-initiated discharge

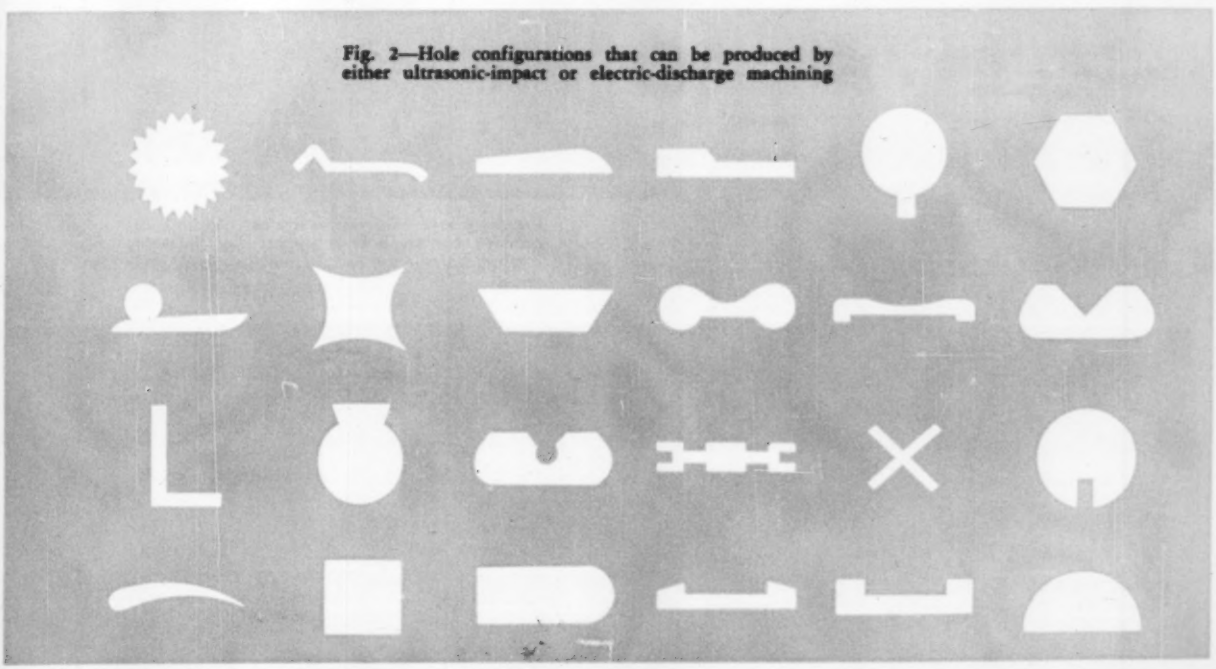


Fig. 2—Hole configurations that can be produced by either ultrasonic-impact or electric-discharge machining

2. Electrolytic-discharge
3. Spark-initiated discharge

Contact-initiated discharge uses a low-voltage, high-amperage, ac power source. The tool is touched to the workpiece to close the circuit and is then withdrawn until an arc is formed. When current flow forms an arc between electrode and workpiece, temperature of the small arc area on the work rises considerably above that of the surrounding material. Since this occurs in the presence of coolant, thermal shock causes small particles of the work to break away from the parent structure. The process is most commonly used to extract broken taps and drills.

Electrolytic-discharge process is somewhat similar. It uses an electrolyte as the conducting medium and is generally applied to grinding or cut-off operations. A source of continuous, low-voltage dc current is connected between a rotating drum and the work, the work being covered by a liquid electrolyte. The disc or drum is the negative and the work the positive electrode.

The electrolyte commonly used in the process is a solution of sodium silicate; at least part of the machining is the result of electrochemical action from current flow. A gap between the electrode and the part is constantly opened and closed by natural vibration of the apparatus during operation, so that arc cutting is also done.

Spark-initiated discharge uses breakdown of a dielectric to initiate a spark and, unlike the first two processes, does not require the tool or electrode to contact the work. Machining is accomplished by a series of discharges, occurring at rates from 20,000 to millions of cycles per second, between tool and workpiece. For each cycle, voltage differential is built up between electrode and workpiece, until electrons bridge the gap to the workpiece at the closest points. A tiny portion of the workpiece is converted to superheated metallic vapor, with a positive charge, that is attracted to the negative electrode. As it starts moving, it is cooled and washed out of the gap by the coolant. While thousands of these discharges occur every second, the material is rapidly removed without heating the workpiece.

Applications: There are two basic applications for spark-initiated, electrical-discharge machining—hole development and surface grinding. The principle and basic methods are identical. All conductive materials, regardless of heat treatment and physical properties, are readily machined. These include carbides, tungsten, hardened toolsteel, cermets, molybdenum, germanium, cobalt, nickel, and titanium.

A 10 to 20 mu in. rms finish can be obtained on parts that cannot be cut conventionally due to hardness. Workpiece shapes that present problems to conventional machining are often produced easily by electrical-discharge machining. Some of these are tapered, cylindrical, or irregular shapes; thin, fragile parts and honeycomb sections; intersecting holes, serrations, and other irregular hole configurations. Fig. 2, 4, and 5. Intricate surface details can be reproduced faithfully, Fig. 6.

Hole diameters, slot widths, and hole spacing can be controlled economically to a tolerance of ±0.0005. It is possible to machine precision holes

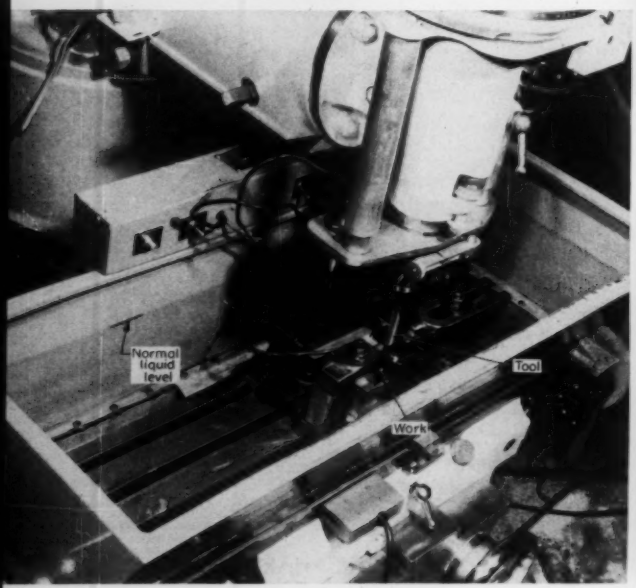


Fig. 3—Work setup on spark-initiated, electric-discharge machine. Coolant pan is filled with dielectric fluid during operation

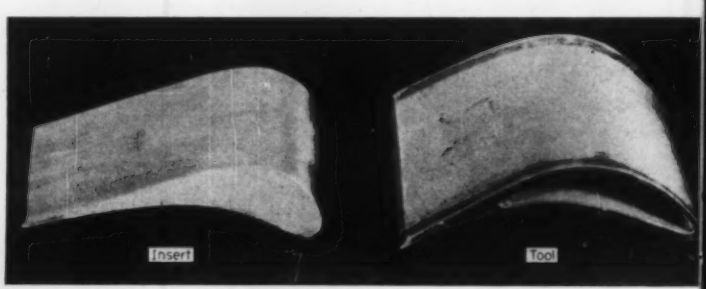
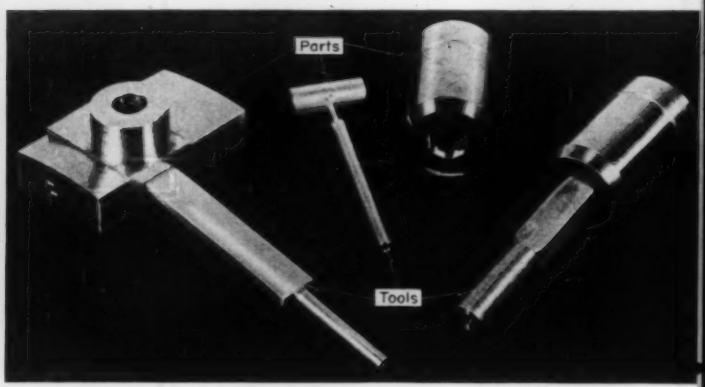


Fig. 4—Above—Air-vane insert and electrode to produce receiving hole in support ring. Below—Typical holes produced in stainless and tool steels



spaced no more than 0.005 in. apart without distortion of the holes or mutilation of the web between holes. For example, 0.158-in. diam holes are machined with a 0.005-in. web in stainless-steel plate 0.093-in. thick.

The process offers a number of significant advantages:

1. Production of multiple cavities and holes of various shapes in any conductive material to tolerances of ± 0.0005 in.
2. Electrodes are readily made from free-machining yellow brass, to any required configuration at low cost.
3. There is no detrimental effect on either microstructure or properties of the material cut.
4. Material removal does not cause stress or warping.
5. Cutting rates are five times faster than conventional methods in materials such as tungsten, carbide, cobalt, and high-speed tool steels.
6. Greater dimensional accuracy and edge definition is produced on all configurations.
7. Holes are usually completed in one operation, eliminating finish operations and handwork for irregular-shaped holes.
8. Small parts formerly made in segments by conventional machining methods can be produced in one piece in less time and at less cost.

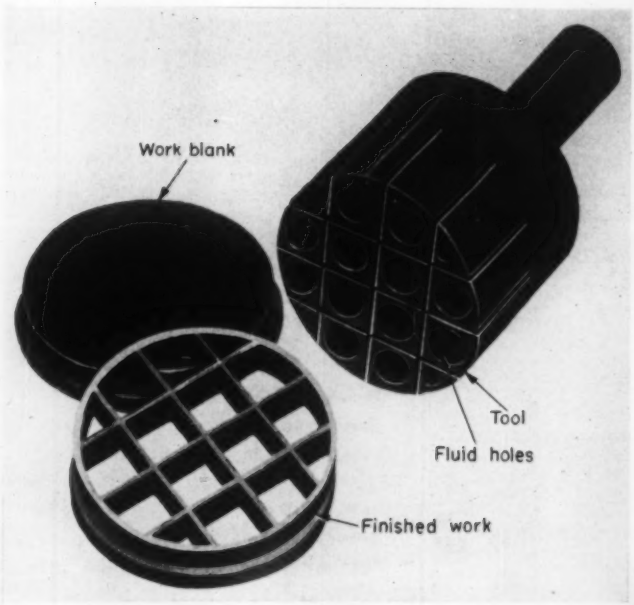
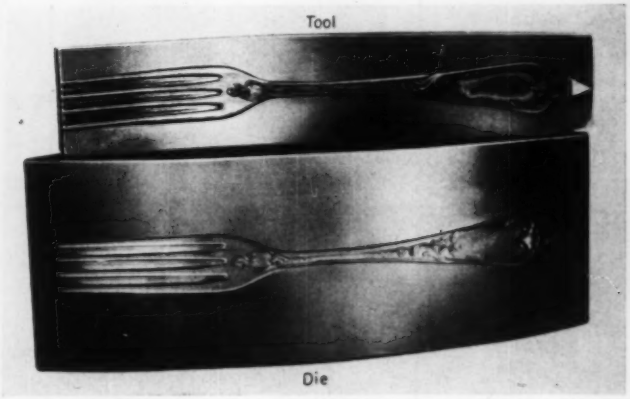


Fig. 5—Intricate grill produced by simple tooling

Fig. 6—Coining dies with fine surface detail are made with easily machined brass tool

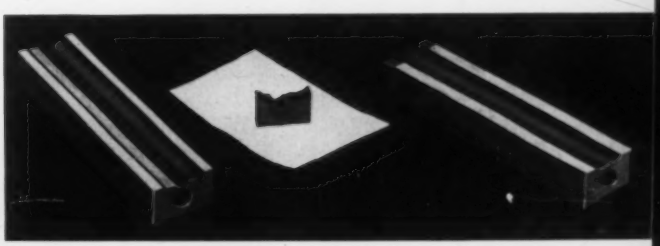


Electrical-Discharge Grinding: A brass "grinding" wheel is used in this process, without abrasives or diamond fragments, to produce tolerances and finishes comparable to those ground by conventional methods, Fig. 7. Cuts of any width or depth within the wheel size can be made in a single pass; reciprocation of work or wheel is not necessary and plunge cuts can be made directly into a workpiece. Where large sections of a part are ground off, cut-off is completed and then the finish cuts are made with the same wheel on a finer setting.

The free-machining brass wheel, formed to suit requirements, is rotated at slow speed—between 100 and 200 rpm. There is little vibration or oil splash, and concentricity is maintained. Since there is no mechanical pressure or spindle vibration, waviness and chatter marks are eliminated. There are no scratches, burrs, or heat checks.

The process offers numerous advantages over conventional grinding:

1. Dissimilar materials, such as carbide and steel, are ground simultaneously with tolerances of ± 0.0002 in. on the contour.
2. Cutting time is less—sometimes less than 30 per cent of conventional-grinding time in hard stock. Present erosion capacity is in excess of 0.03 cu in. per minute for metal carbides.
3. There are no detrimental effects on either microstructure or properties of material cut.
4. A fine matte surface finish, excellent edge definition, and great accuracy are produced.
5. Electrode wheels are inexpensive.
6. Process does not create stress or warpage.



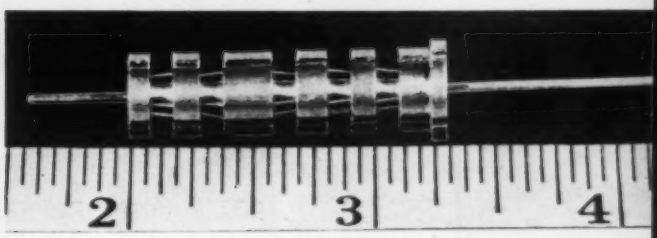
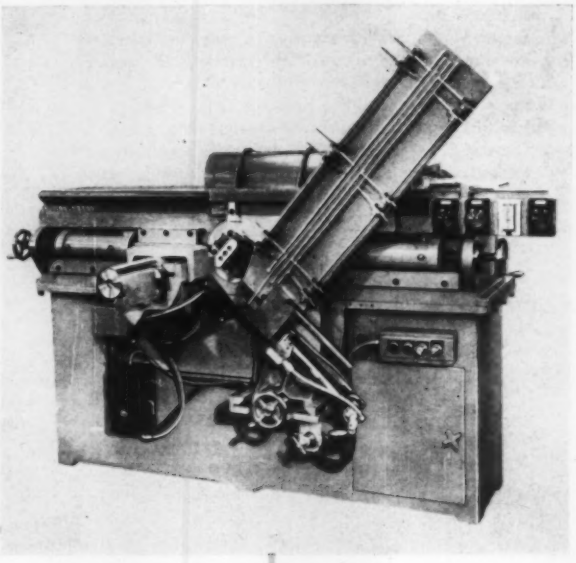


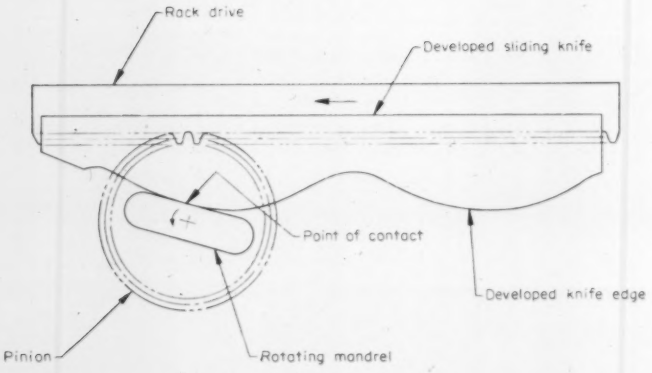
Fig. 7—Above—Long contoured parts are ground in one pass. Below—Tungsten-carbide servo piston is rotated during plunge grinding of 0.050-in. wide grooves to 0.062-in. root diameter

Odd-Shaped Shells Trimmed

Automatic trimming of odd-shaped drawn shells is accomplished at high speeds in a new machine designed by Dayton Rogers Mfg. Co., Minneapolis, Minn. The machine will trim any shape of shell, within its capacity limitations, except extreme concave sections. Shells with high length-to-width ratios are easily handled. As reported by Robert M. Gold, chief engineer, the equipment makes use of design principles which enable it to trim shells at rates up to 800 per hr.

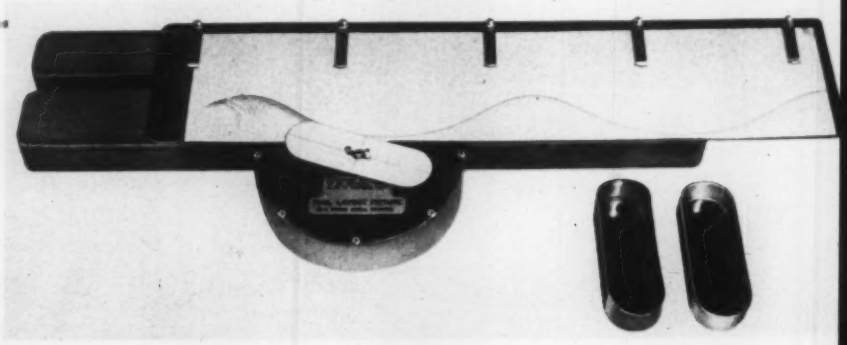
The machine is built with a heavy slide meshed through a rack and pinion to a rotating spindle. A mandrel, which closely fits the shell, is mounted to the spindle and a developed knife is clamped to the slide.



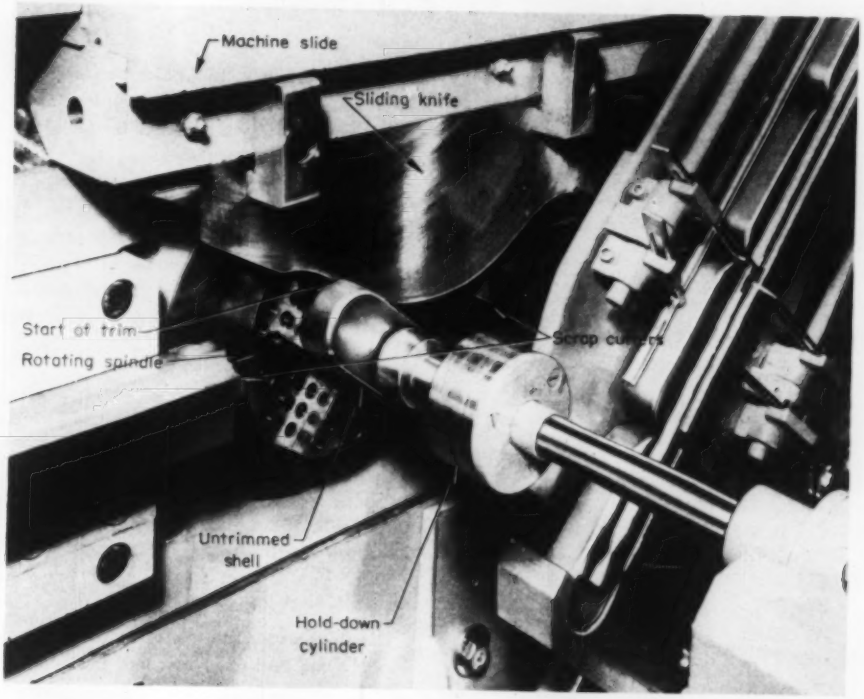


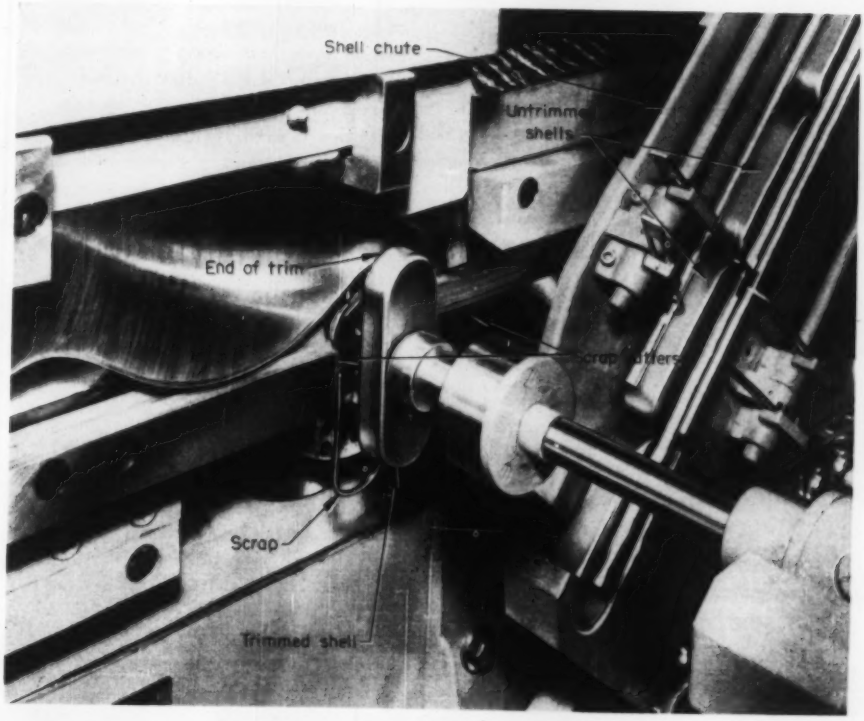
Developed sliding knife design gives constant overlap with mating rotating mandrel at the point of contact. In effect, all power is then concentrated at the point of cutting without changes in direction of force application, even though irregularly shaped shells are being trimmed.

Cardboard knife templates are made easily and quickly with a tool layout fixture which is included with each machine. The action of the fixture is the same as the trimmer, having the same stroke on the slide and meshing with a spindle gear of the same pitch diameter.



With Sliding-Knife Cutting Action

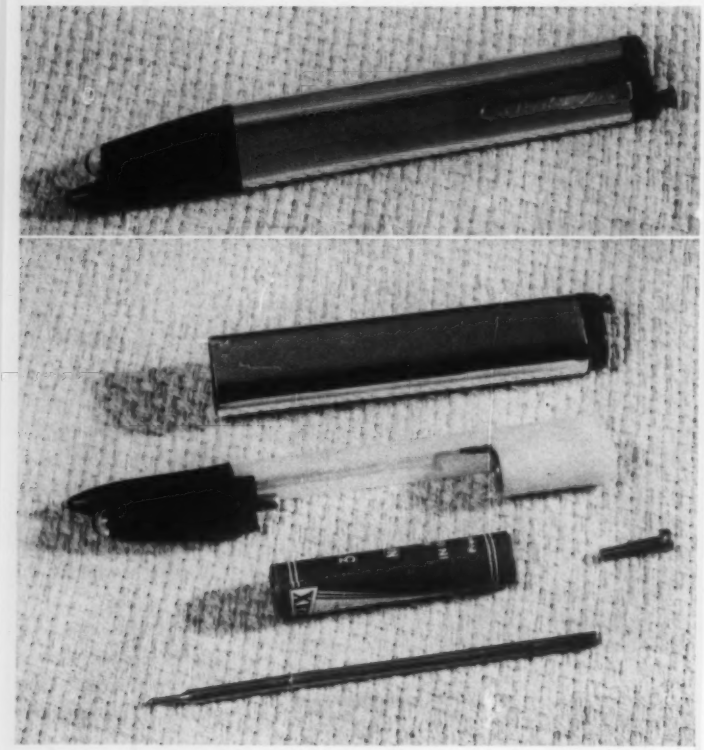




Slicing action rather than shearing permits trimming with less unit force. At the point of contact, knife travels at a higher lineal speed than the rotating shell. The spindle pinion is driven by the slide rack. For one revolution of the spindle, the rack must travel a distance equal to the perimeter of the pinion pitch diameter. Unless the shells, which are mounted on the spindle, have exactly the same pitch diameter as that of the spindle pinion, there will be relative motion between knife and shell. This condition produces the slicing action.

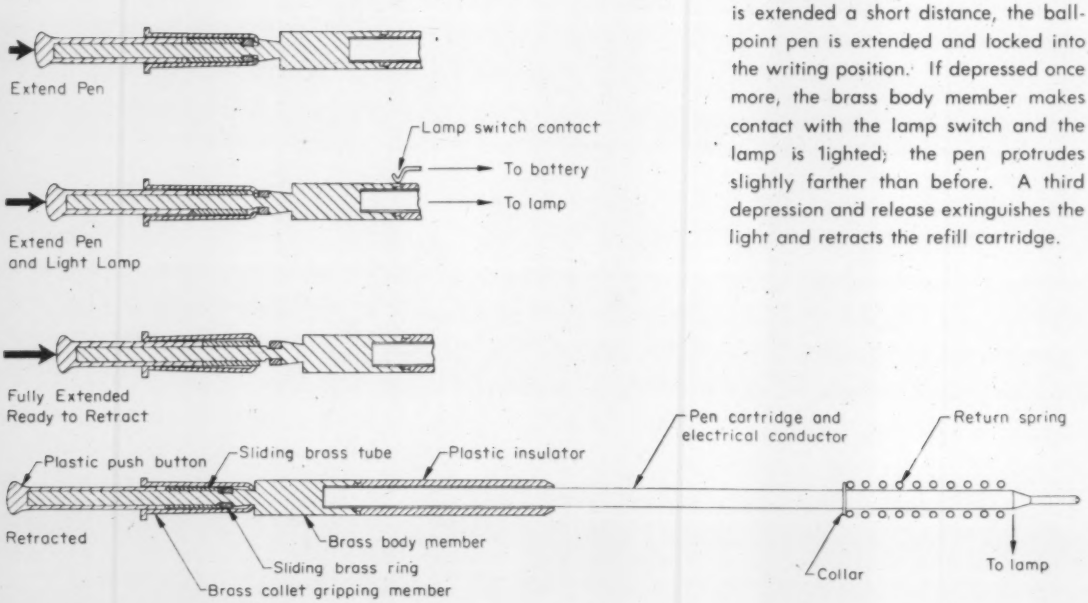
Operation becomes fully automatic when a shell from feeder chute breaks a photoelectric beam and sets the cycle into motion.

Single Pushbutton Operates Combination Pen and Flashlight



Built-in lighting in ball-point pen permits writing where ambient light-levels are quite low. As reported by Monterey International, Monterey, Calif., the lamp is operated by either a standard 3-v cell or two 1.5-v cells. To remove the battery (or batteries) it is only necessary to remove a screw fastener at the top of the unit and slip off the cover of the combination unit.

Thumb-operated pressure mechanism brings the ball-point pen into position and turns the lamp on and off. Proper operation depends on the action of a collet member which is slotted at one end to form four spring-loaded gripping fingers. If the plastic pushbutton is extended a short distance, the ball-point pen is extended and locked into the writing position. If depressed once more, the brass body member makes contact with the lamp switch and the lamp is lighted; the pen protrudes slightly farther than before. A third depression and release extinguishes the light and retracts the refill cartridge.



Wear Characteristics of

Fine-Pitch Gear Materials

This evaluation of all-metal and plastic-metal gear combinations for spur-gear meshes provides a tool with which designers can estimate wear rates of a gear mesh

By R. J. BENSON
Bell Telephone Laboratories
New York, N. Y.

PRECISION gear trains require materials which wear at a minimum rate for applications where accurate input-output relationships are necessary.

Wear studies of 48 spur-gear meshes of various material combinations reveal marked variations in backlash increase with reference to elapsed running time. Backlash increase due to wear varies from 0.0002 in. for a steel-aluminum combination, to 0.0244 in. for an aluminum-aluminum combination after 2000 hr of running. Gear-material combinations and test duration time for each mesh are shown in Table 1.

Metallic Materials: All aluminum gears were machined from Type 2024-T3 alloy, but only those for certain meshes were anodized as indicated. Corrosion-resistant steel, Type 416 heat treated to Rockwell C 25 to 30 before machining, was used for all steel gears. After machining, all gears which required finishing were measured over pins so that effects of finish on dimensions could be determined.

Table 1—Gear Material Combinations and Test Duration

Mesh Number	Lubricated*	Gear Materials		Test Time (hr)	Test Observation
		Pinion Gear	Driven Gear		
1 and 2	No	Aluminum	Aluminum	421	Excessive initial wear
3 and 4	No	Steel	Aluminum	2000	Constant wear rate
5 and 6	No	Anodized aluminum	Anodized aluminum	1156	Loss of anodized finish at 750 hr
7 and 8	No	Steel	Anodized aluminum	2000	Minute traces of wear products
9 and 10	Yes	Aluminum	Aluminum	2000	Minute traces of wear products
11 and 12	Yes	Anodized aluminum	Anodized aluminum	2000	Minute traces of wear products
13 and 14	Yes	Steel	Aluminum	2000	No evidence of wear products
15 and 16	Yes	Steel	Anodized aluminum	2000	No evidence of wear products
17 and 18	No	Anodized aluminum	Aluminum	2000	Rapid wear rate, 0.002 in./100 hr
19 and 20	Yes	Anodized aluminum	Aluminum	2000	Constant wear rate
21 and 22	No	Rulon B	Anodized aluminum	700	Rapid wear rate of anodized aluminum
23 and 24	No	Nylon 3001	Anodized aluminum	2000	No evidence of wear products
25 and 26	No	Nylasint 66	Anodized aluminum	2000	Slight pitting of aluminum gear
27 and 28	No	Nylasint 64	Anodized aluminum	2000	Slight pitting of aluminum gear
29 and 30	Inherent†	Nylasint 66-6G	Anodized aluminum	2000	Slight trace of wear products
31 and 32	Inherent†	Nylasint 64-6G	Anodized aluminum	2000	Slight trace of wear products
33 and 34	Inherent†	Nylasint 66-MS	Anodized aluminum	2000	Minute trace of wear products
35 and 36	Inherent†	Nylasint 64-MS	Anodized aluminum	2000	Minute trace of wear products
37 and 38	No	Electrolized aluminum	Electrolized aluminum	96 and 138	Excessive initial wear on driven gear
39 and 40	No	Electrolized steel	Electrolized aluminum	480	Major wear on driven gear
41§	No	Steel	Anodized aluminum	238	Excessive initial wear
42	No	Steel	Aluminum	238	Excessive initial wear
43	Yes	Steel	Anodized aluminum	480	Slight pitting and finish removal
44	Yes	Steel	Aluminum	480	Slight pitting and finish removal
45	Yes	Aluminum	Aluminum	480	Original tooth profile gone
46	Yes	Anodized aluminum	Anodized aluminum	383	Rapid backlash increase at 342 hr
47	No	Nylon 3001	Anodized aluminum	480	Slight pitting of driven-gear teeth
48	No	Nylon 3001	Aluminum	480	Slight pitting of driven-gear teeth

*General-purpose lubricant for temperatures from −65 to +250 F applied only once (before start of test).
†Nylasint Types —6G and —MS have graphite and MoS_2 respectively added for lubricity. Types 64 and 66 were impregnated with SAE 30 at 200 F for 30 min prior to test.
§Meshes 41 through 48 were temperature cycled during testing from −65 to +200 F once per 24 hr.

An additive finish was applied to both the aluminum and steel gears for certain meshes by electrolizing. The process deposited a finish of 90 per cent chrome at Rockwell C 70 to 72 hardness on the base metal. The measurement over pins for all finished gears decreased by an average of 0.0001 in. due to anodizing and increased by an average of 0.0002 in. due to electrolizing. Characteristics of all gears used in the meshes are shown in Table 2.

Table 2—Gear Characteristics

Gear	Teeth	Diametral Pitch	Pressure Angle (deg)	Face Width (in.)	Precision Class (AGMA)
Pinion	48	48	20	0.250	1
Driven	97	48	20	0.250	1

Table 3—Gear Backlash Increase Due to Material Wear

Backlash Increase (in.)	Mesh Number	Backlash Increase (in.)	Mesh Number
0.0002	15	0.0020	19
0.0003	10	0.0022	29
0.0004	14	0.0022	39*
0.0005	16	0.0022	43*
0.0005	28	0.0024	30
0.0007	9	0.0031	44*
0.0007	13	0.0045	47*
0.0007	26	0.0048	48*
0.0008	11	0.0068	45*
0.0008	23	0.0071	3
0.0008	24	0.0076	38*
0.0008	36	0.0092	4
0.0009	25	0.0093	22
0.0009	35	0.0106	21
0.0009	40*	0.0107	2
0.0010	32	0.0111	41*
0.0011	7	0.0117	46*
0.0011	8	0.0120	42*
0.0012	12	0.0120	37*
0.0012	27	0.0124	6
0.0012	33	0.0129	5
0.0013	20	0.0172	1
0.0017	31	0.0181	17
0.0017	34	0.0244	18

*Pitch line velocity=471 fpm. All others 113 fpm.

Plastic Materials: Driving-gear materials for certain mesh combinations include Rulon B (a modified Teflon), nylon Type 3001 (Zytel 31), and Nylasint, indicative of a group of sintered-nylon products.

Nylasint 66 materials have the same structure as Dupont's Zytel 101 (formerly Nylon FM10001), and the Nylasint 64 materials are combinations of nylons with FM10001 as the major constituent.

Test Results: All test meshes were loaded by means of a prony brake which applied a torque of approximately 200 gm-in. throughout the tests. Increase in backlash, the difference between an initial and final backlash measurement, is shown in Table 3.

The combination of a heat-treated, corrosion-resistant steel pinion and an anodized aluminum gear provides excellent wear resistance. Anodizing greatly increases wear life of aluminum gears. Lubrication of gear teeth decreases wear in combinations of aluminum, anodized aluminum, and corrosion-resistant steel (meshes 1 through 20).

A mesh of anodized and unanodized aluminum gears shows good wear properties if lubricated. Without lubrication, the combination fails quickly. Meshes that fail under ordinary conditions show satisfactory wear life when lubricated. This is useful in a gear train, for example, where inertia is a problem and lightweight materials are desirable.

Except for the Rulon B and anodized-aluminum combination, all plastic meshes have good wear characteristics. Nylon 3001 and Nylasints 64, 66, and 64-MS have approximately the same rate of wear and all show excellent wear life.

An all-aluminum mesh (both gears electrolized) shows poor wear resistance. The mesh of an electrolized, corrosion-resistant steel pinion and electrolized aluminum gear shows satisfactory wear properties.

Under conditions of temperature cycling, the lubricated mesh of a corrosion-resistant steel pinion and an anodized aluminum gear exhibits excellent wear resistance. A mesh of this combination is superior to a similar one in which the aluminum gear is not anodized. Also, the mesh of an anodized aluminum gear with a nylon pinion is superior to one in which the aluminum gear is not anodized.

Tips and Techniques

Determining Moment of Inertia

To determine the polar moment of inertia of a perfectly balanced, pivoted mass which is not easy to remove or to handle, such as the rotor of an electric motor, one can not use the usual method of obtaining the moment of inertia about another axis and then transferring it to the centroid axis. Instead, a simple method can be used to advantage.

Attach a known weight, W, to the mass at a distance l from the axis of rotation. In case the mass is not accessible and the shaft rotates with it, attach the weight to the shaft with a light, rigid rod of length l. Set the system in oscillation at amplitudes of 10 deg or less and measure the period, T. Then apply

$$J = Wl\left[\left(\frac{T}{2\pi}\right)^2 - \frac{l}{g}\right]$$

where g is the acceleration of gravity. The answer, J, is in units of lb-in-sec.^{2}—E. MARTINEZ, *consulting mechanical engineer, Princeton, N. J.*

Human-Factors Engineering—5

Fitting Man and Machine

By JOHN D. VANDENBERG, Occupational Research Center
Purdue University
Lafayette, Ind.

EVALUATED from a strictly dimensional standpoint, people have been called "adjustable" and, on occasion, even "compressible." Many humans—particularly those who are larger or smaller than average—may feel that these characteristics have been overestimated.

Where the concern of a systems designer is with the comfort, efficiency, and safety of a human operator, the following rule-of-thumb is almost axiomatic: There is no one best dimension for any object that is designed for use by human beings. It follows, therefore, that such objects should be either: 1. Adjustable. 2. Designed to accommodate normal deviation and range in human body dimensions.

Variations in body size are important factors in the design of control areas of all kinds (including those in automobiles and other mobile equipment), working areas for seated operators, passageways and aisles, clothing and protective equipment, and hand tools and equipment. This article summarizes accepted techniques for fitting the design to the man by selecting the correct body-size data.

Average or Percentile?

Inadequate design from an anthropometric (human body size) point of view can usually be traced to one of the following factors:

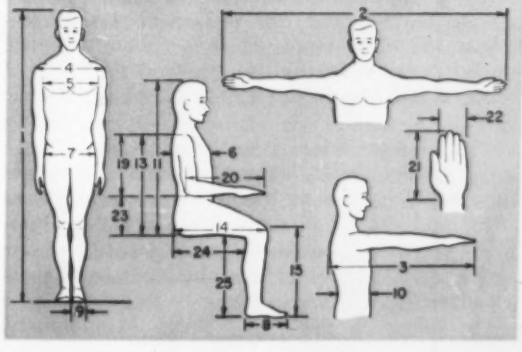
1. The designer has selected a "typical person" and sized an object to fit.
2. A statistical average of multiple measurements of a given dimension has been obtained, and the object has been designed accordingly.
3. Information concerning a significant body dimension is not available.

The "average-man" concept is a particularly serious fallacy in equipment design. In fact, sure-

Table 1—Male Figure Dimensions

Key Number	Measurement	Dimension (in.) 5 percentile	50 percentile	95 percentile
1.	Height	64.2	68.2	72.5
2.	Total arm span*	66.5	70.9	75.5
3.	Forward arm reach*	32.9	35.8	38.4
4.	Shoulder breadth	16.6	17.9	19.7
5.	Chest breadth	10.0	11.1	12.4
6.	Chest depth	7.3	8.3	9.6
7.	Hip breadth	10.3	11.4	12.9
8.	Foot length	9.7	10.4	11.2
9.	Foot breadth	3.5	3.9	4.3
10.	Abdominal depth	8.0	9.0	10.5
11.	Erect sitting height	33.5	35.7	37.9
12.	Normal sitting height*	32.6	34.7	36.6
13.	Seat-shoulder height	20.9	23.0	24.9
14.	Buttock-knee	21.5	23.3	25.2
15.	Knee height	19.8	21.6	23.4
16.	Elbow breadth	15.3	17.5	20.3
17.	Seat breadth	12.7	13.8	15.4
18.	Knee breadth*	7.3	8.1	9.2
19.	Shoulder-elbow height	13.0	14.3	15.5
20.	Elbow-middle finger	17.2	18.7	20.1
21.	Hand length	7.0	7.6	8.2
22.	Hand breadth	3.2	3.5	3.8
23.	Seat-elbow height†	8.2	9.6	11.0
24.	Seat length†	17.4	18.9	20.4
25.	Seat height†	17.6	19.0	20.4

*Based on measures of 311 civilian truck drivers by McFarland.[3]
†Based on measures of 1959 civilian males by Hooten.[3]
All other dimensions based on 2000 Army truck drivers (McFarland[3]).



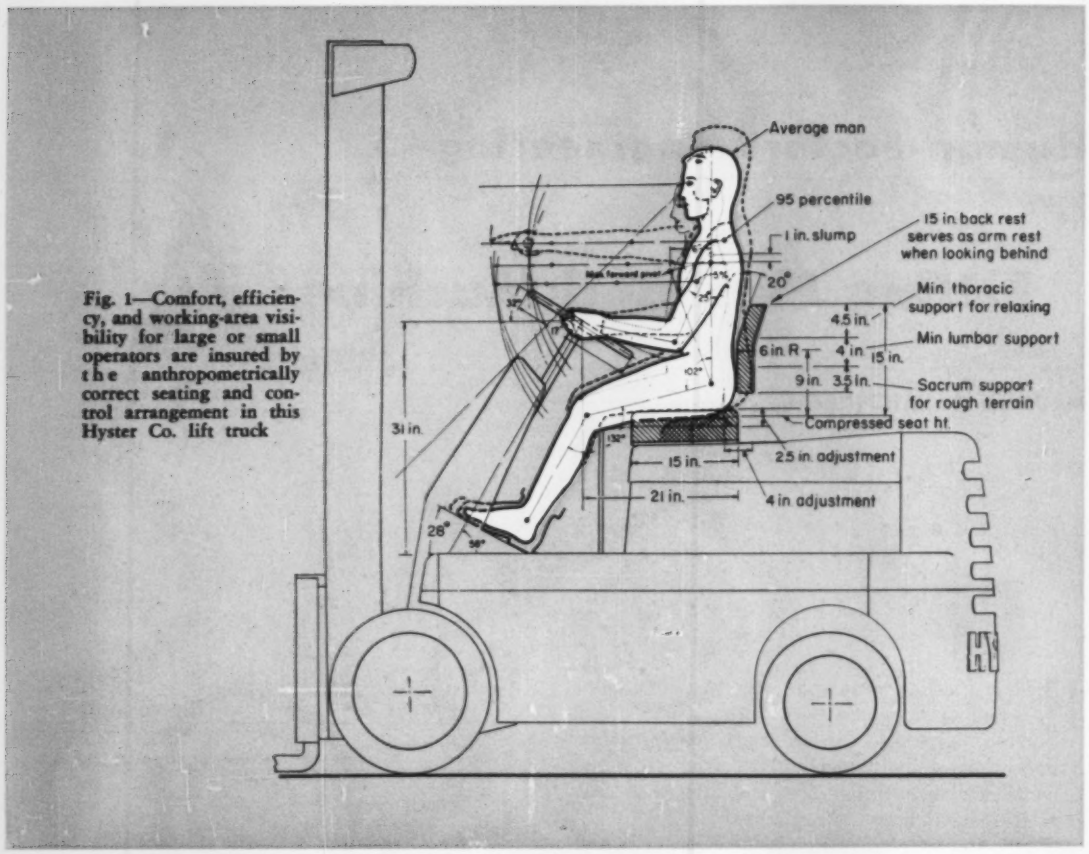


Fig. 1—Comfort, efficiency, and working-area visibility for large or small operators are insured by the anthropometrically correct seating and control arrangement in this Hyster Co. lift truck

fire prescription for discomforting 40 to 50 per cent of the potential users of an item is to design it to fit the average man. Distribution of normal sitting height illustrates this point. Table 1 shows that the average (50th percentile) erect sitting height for truck drivers is 35.7 in. Furthermore, 5 per cent sit no higher than 33.5 in., and 5 per cent measure 37.92 in. or higher. If a truck cab were dimensioned to fit the average driver and seat height were fixed, big men would bump their heads, and small men might have trouble seeing over the steering wheel.

A few years ago, a manufacturer constructed two life-sized manikins (one male and one female) as the basis for designing millions of dollars worth of equipment. Because the average and not the extremes of body-size distribution was used in proportioning the manikins, the equipment was uncomfortable for many users. In fact, it was dangerous, since it induced fatigue and obscured the vision of operators who were smaller or larger than the average.

This example is not intended to deny that such manikins are useful. There are occasions where the designer must work with the same body dimensions repeatedly in different design problems. Templates and two-dimensional models greatly facilitate this work, and many designers have employed them to advantage.

Depending on the nature of the item, the designer should dimension for the smallest user or operator, or for the largest, or for both. In theater-seat layout, for example, leg-room space should at least be adequate for the larger patrons. Floor pitch, on the other hand, should be made steep enough to allow the small person to see over the head of a large person sitting in front of him. In vehicle seat design, Fig. 1, both large and small drivers should be considered, and seat adjustability is necessary so that either can drive comfortably and safely.

In body-dimension data, the term "percentile" is encountered repeatedly. For the purposes of this discussion, percentile may be defined as showing the per cent of a selected group of subjects who are *equal* to or *smaller* than the remainder with respect to a given dimension. Thus, a male who is 6 ft ½ in. tall is at the 95th percentile (Table 1) when compared with civilian truck drivers. This means that 95 per cent of civilian truck drivers are equal to or less than 6 ft ½ in. tall.

Returning to the theater seat arrangement: The appropriate 95th percentile measurement can be used to locate seats so that people with long legs will have enough room. When deciding on floor slope, the designer should consider the 5th-percentile group with regard to eye-level height so that the short people can see over the heads of the tall.

There is no firm rule that requires the use of 5th and 95th-percentile body dimensions, although

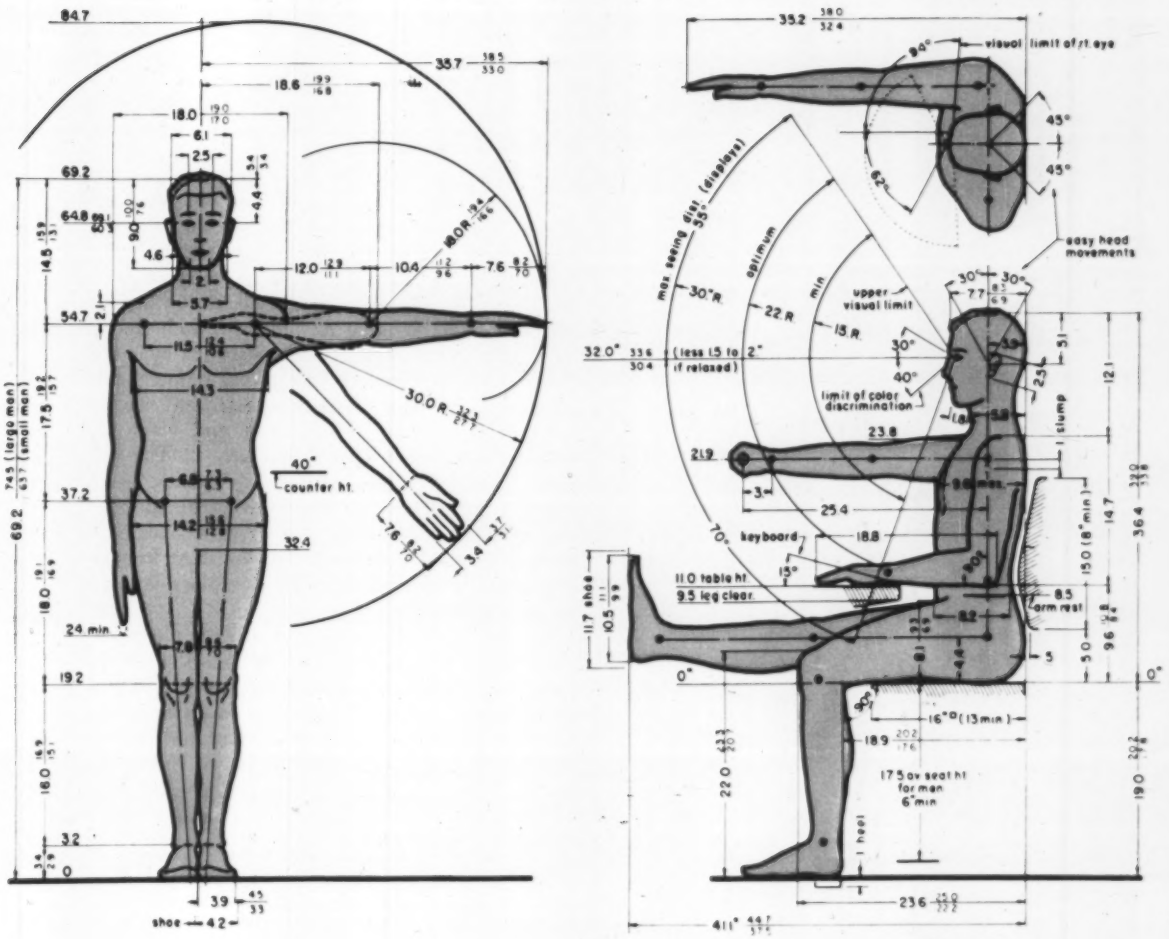


Fig. 2—Body-dimension distribution varies slightly with the occupation of the group sampled. Compare dimension ranges shown here for large, small, and average industrial workers with those listed in Table 1 for Army truck drivers

it is common practice. Generally, it is not considered economically feasible to design for the very few people who fall outside these limits. There may be occasions, however, where use of narrower limits is justified.

Interpreting Body-Size Data

Considerable information is available giving the dimensions of men, women, and children. Table 1, for example, lists the most frequently used measurements for male adults. It should be noted that results credited to McFarland refer only to bus and truck drivers. Measurements taken of members of other occupational groups, or of the general public, cannot be expected to agree precisely with the dimensions listed in Table 1. As an example, Fig. 2 shows industrial-worker dimensions used by Henry Dreyfuss in determining the best control and seating arrangements for a Hyster Co. lift truck.

Design problems often arise that require a body dimension which is not available in the literature. In some cases, the missing dimension can be obtained by simple addition or subtraction of dimensions that are given. In other cases, the desired dimension cannot be obtained so simply, and the designer may be tempted to extend 95th percentile data incorrectly.

For example, assume that a designer selects a subject who falls at the 95th percentile in a dimension that is given in the literature. He then measures the desired dimension on the same subject, and this dimension is assumed to represent the 95th percentile value for the unknown dimension. This procedure is wrong, however, since the various measurements of an individual are not closely related in this fashion.

Take sitting height, for example: If a person is selected who falls at the 95th percentile in stature (assuming that these data were available), the chances are only about 1 in 5 that the same subject

Fig. 3—Over-all dimensions for subjects wearing arctic clothing can be taken from scaled photos like this one prepared by Army's Quartermaster Research and Development Command

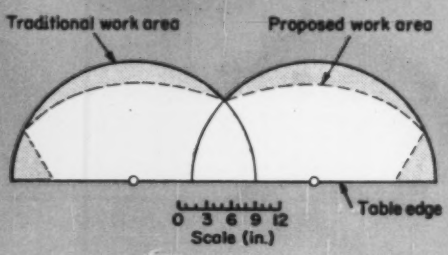


Fig. 4—Comparison of traditional work area, drawn by striking arc from shoulder, with the functionally correct area determined by the methods of Reference 13

will also fall at the 95th percentile with regard to sitting height. In fact, a person at the 95th percentile in stature can have a sitting height as low as 33.1 in. or as high as 40.1 in. The 95th percentile for sitting height is about 38.2 in. McFarland presents additional information concerning the relation between various body dimensions in Reference 8.

Designers who must accommodate people wearing bulky clothing are faced with an additional problem, since most available body-dimension measurements are made on nude subjects. The Army's Quartermaster Research and Development Command has developed a valuable technique for dealing with this problem, as well as with the problem of obtaining dimensions that have not been measured directly.

Under carefully controlled conditions, photographs are taken of a person wearing arctic clothing. The subject selected is one whose important dimensions all fall at or above the 95th percentile. He is photographed in a variety of postures, and a scale is added to each print so that any desired dimension can be readily obtained. Fig. 3 shows a representative result.

▶ Work-Area Layout

In using body dimensions to lay out work areas, the designer must make use of accurate data on the movements possible for the various limbs. It is not permissible, for example, to set a compass for the length of an arm, and then to determine the maximum reach by striking an arc from each shoulder. This point is convincingly demonstrated by a recent Naval Medical Research Laboratory report[15], which compares: 1. The "normal work area" (reached with movements of the forearm and wrist only) obtained by drawing a simple arc. 2. The actual area obtained when normal movement of the joints is considered. The areas obtained by the two methods are compared in Fig. 4. Specific recommendations for dealing with the most frequently encounted design problems in workplace layout are given in Reference 2.

In the next article of this series, methods for systematically applying human-factors data to a variety of design situations are reviewed. Also presented are a listing of sources of such data and a commentary on their general content and approach.

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Finding deflections of

Arched Cantilever Beams

with graphical aids

By ALEXANDER BLAKE
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Associated Spring Corp.
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IN THE design of certain types of structures, the engineer frequently deals with a redundant frame member formed in a circular arc, subtending any angle, and loaded in any direction. One end is considered fixed, while the other is displaced by the application of forces and moments. From the relation between loading and deflection at the free end, the magnitude and direction of reactions can be found. When all forces including reactions are known, stresses can be calculated. Deflection analysis may often be simplified by assuming the circular member to be relatively thin, allowing the contributions of shear and direct stresses to total deflection to be neglected.

Derivation of design formulas for deflection of curved members is accomplished by use of Castigliano's theorem and expressions for strain energy due to bending. Strain energy may be defined as the mechanical energy stored up in an elastically stressed system which can be recovered upon removal of external loads. Castigliano's principle states that when total strain energy, expressed in terms of external loads and couples, is partially differentiated with respect to a given external load, the result gives displacement of that load in its own line of action.

To find deflection of a structure at a point other than at which a given external load, P, is applied, use is made of a fictitious load, V, of an infinitely small value, acting in the direction of the required displacement, Fig. 1. The bending-moment equation is then expressed in terms of all the real and imaginary loading, and total strain energy is differentiated with respect to V. The imaginary load is made equal to zero and the deflection formula obtained.

The procedure for finding fundamental equations for vertical and horizontal deflections is based upon

$$Y = \frac{r}{EI} \int_0^{\psi} M \frac{\partial M}{\partial V} d\theta \qquad (1)$$

and

$$X = \frac{r}{EI} \int_0^{\psi} M \frac{\partial M}{\partial H} d\theta \qquad (2)$$

Equations 1 and 2 apply to relatively thin circular members of constant cross section and are valid within the elastic range of the material. Integration should be extended over the entire length of the arched cantilever.

Deflection Due to Vertical Load: An arched cantilever subtending angle ψ carries a concentrated vertical load, P, at a point at angle β from the free end and a system of two fictitious loads, V and H, acting at a point at angle α from the free end. Angle α can either be smaller or greater than β, Fig. 1. The

Nomenclature

E = Modulus of elasticity, psi
H = Horizontal fictitious load, lb
I = Moment of inertia of arch cross section, in.^{4}
K_x = Function for horizontal deflection
K_y = Function for vertical deflection
M = Total bending moment, lb-in.
M_0 = External couple, lb-in.
M_x = Bending moment due to transverse uniform load, lb-in.
P = Concentrated external load, lb
q = Transverse unit load, lb per circumferential in.
r = Radius of arched cantilever, in.
V = Vertical fictitious load, lb
X = Horizontal deflection, in.
Y = Vertical deflection, in.
α = Angle at which deflection is considered, rad
β = Angle at which external force is applied, rad
θ = Angle at which bending moment is considered, rad
ε = Auxiliary angle for uniform loading, rad
ψ = Angle subtended by arched cantilever, rad

general bending-moment equation, obtained from the geometry of the arch and for all loads acting at points within angle θ, is

$$M = Pr(\cos\beta - \cos\theta) + Vr(\cos\alpha - \cos\theta) + Hr(\sin\theta - \sin\alpha) \quad (3)$$

Substituting Equation 3 into Equations 1 and 2, integrating over the entire length of the arch, and then cancelling imaginary loads V and H, provides for $\alpha < \beta$:

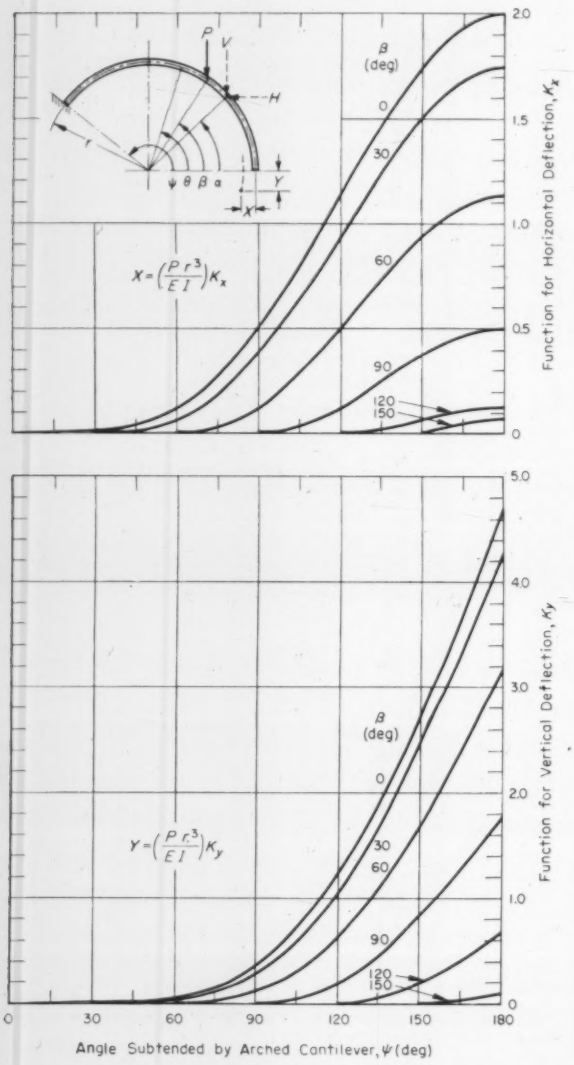


Fig. 1—Values of functions K_x and K_y for deflection due to vertical load

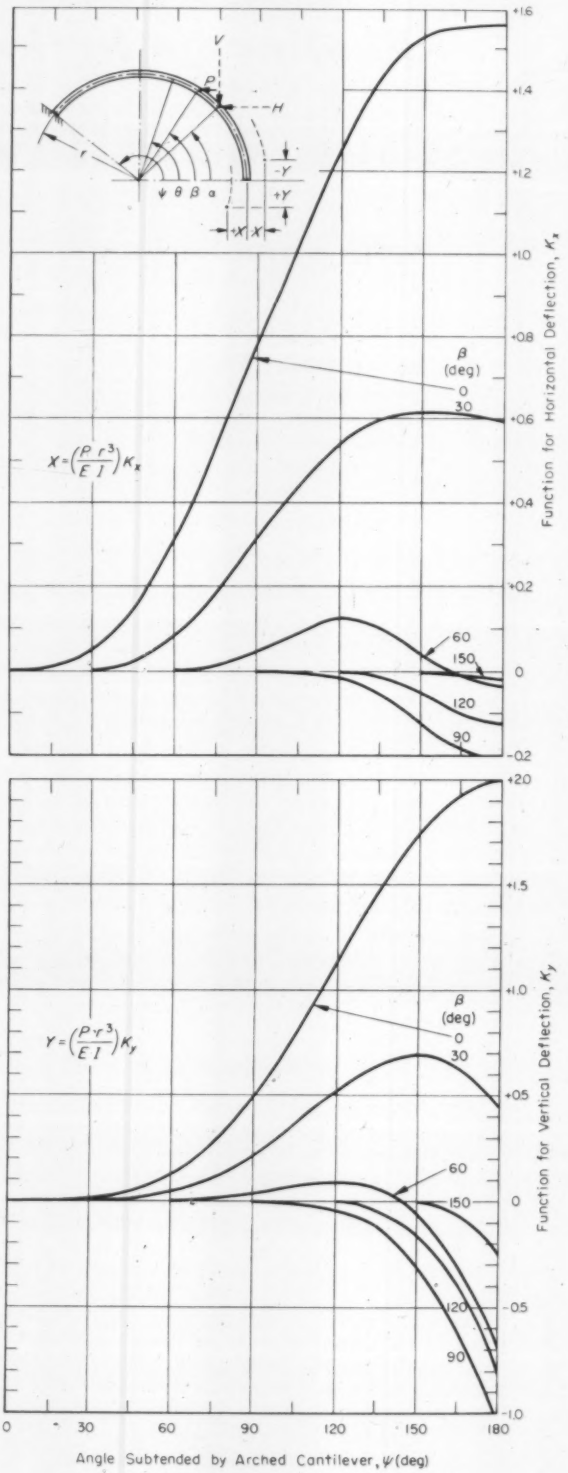


Fig. 2—Values of functions K_x and K_y for deflection due to horizontal load

$$Y = \frac{Pr^3}{EI}\left[(\psi - \beta)\cos\alpha\cos\beta - (\cos\alpha + \cos\beta) \times (\sin\psi - \sin\beta) + 0.5(\psi - \beta) + 0.25(\sin 2\psi - \sin 2\beta) \right] \quad (4)$$

$$X = \frac{Pr^3}{EI}\left[\sin\alpha(\sin\psi - \sin\beta) - (\psi - \beta)\sin\alpha\cos\beta + \cos\beta(\cos\beta - \cos\psi) + 0.25(\cos 2\psi - \cos 2\beta) \right] \quad (5)$$

For cases when $\alpha > \beta$,

$$Y = \frac{Pr^3}{EI}\left[(\psi - \alpha)\cos\alpha\cos\beta - (\cos\alpha + \cos\beta) \times (\sin\psi - \sin\alpha) + 0.25(2\psi + \sin 2\psi - 2\alpha - \sin 2\alpha) \right] \quad (6)$$

$$X = \frac{Pr^3}{EI}\left[\sin\alpha\sin\psi + \cos\beta(\cos\alpha - \cos\psi) - (\psi - \alpha)\sin\alpha\cos\beta - \sin 2\alpha + 0.25(\cos 2\psi - \cos 2\alpha) \right] \quad (7)$$

These equations are valid within the elastic range and can be used to determine vertical and horizontal displacements for all values of α, β, and ψ between 0 and 180 deg. In general, the design equations may be expressed as

$$Y = \frac{Pr^3}{EI} K_y$$

and

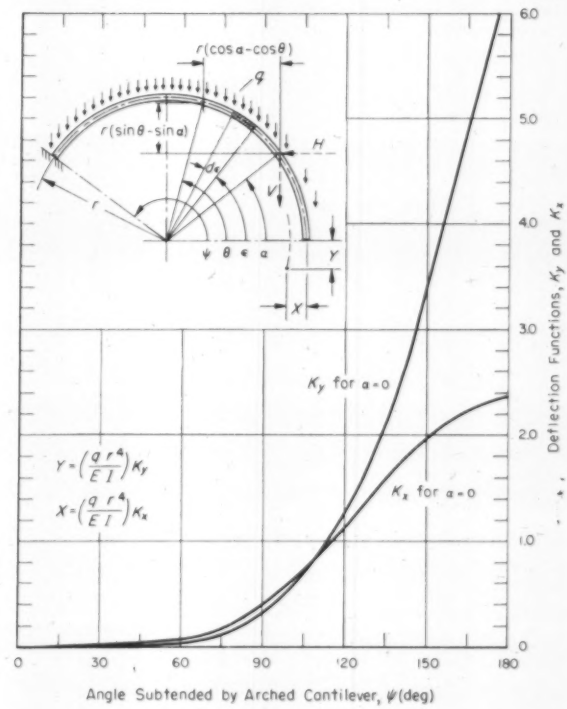


Fig. 3—Values of function K_x and K_y for deflection due to uniform load

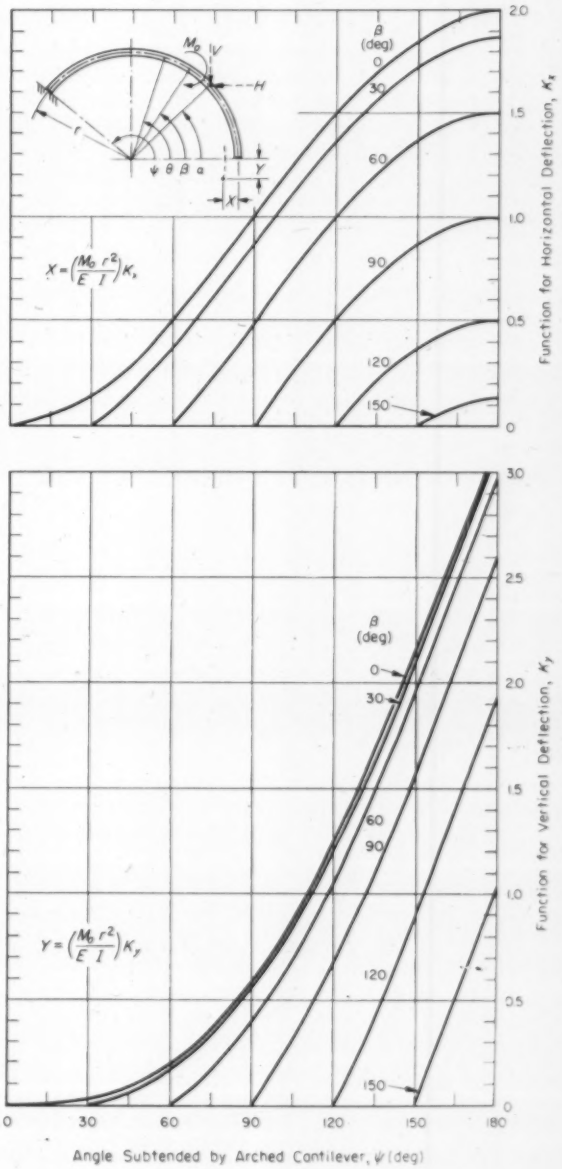


Fig. 4—Values of functions K_x and K_y for deflection due to a couple

$$X = \frac{Pr^3}{EI} K_x$$

where K_y and K_x denote functions of α, β, and ψ which can be evaluated for several cases and arranged in the form of families of curves. The most frequently required displacements are those for which $\alpha = 0$; for this case, Equations 4 and 5 have been plotted in Fig. 1. Positive sign for K_y indicates downward deflection, and positive sign for K_x signifies horizontal displacement to the left.

Deflection Due to Horizontal Load: When a system of two fictitious loads, V and H, and one real load, P, acts horizontally as shown in Fig. 2, the procedure for derivation of the deflection formulas is identical with the previous case. The bending moment at a section defined by θ is

$$M = Pr(\sin\theta - \sin\beta) + Vr(\cos\alpha - \cos\theta) + Hr(\sin\theta - \sin\alpha) \quad (8)$$

Equation 8 is used in conjunction with Equations 1 and 2; integrating along the arch and ignoring all terms involving fictitious loads produces equations for X and Y which may be expressed as

$$Y = \frac{Pr^3}{EI} K_y$$

and

$$X = \frac{Pr^3}{EI} K_x$$

Functions K_y and K_x for $\alpha = 0$ are plotted in Fig. 2 for several angles of β and ψ.

Deflection Due to Uniformly Distributed Load: Deformation of an arched cantilever under a circumferential uniform load, Fig. 3, can be evaluated by finding the elementary vertical load $qrd\varepsilon$, and the bending moment, $dM_x = qr^2(\cos\varepsilon - \cos\theta)\,d\varepsilon$. After integration between limits of 0 and θ, $M_x = qr^2(\sin\theta - \theta\cos\theta)$ is found. Therefore, total bending moment at a section defined by θ is

$$M = qr^2(\sin\theta - \theta\cos\theta) + Vr(\cos\alpha - \cos\theta) + Hr(\sin\theta - \sin\alpha) \quad (9)$$

Deflection formulas are obtained by integration after combination of Equations 1 and 2 and 9, and are expressed as

$$Y = \frac{qr^4}{EI} K_y$$

and

$$X = \frac{qr^4}{EI} K_x$$

Design curves corresponding to vertical and horizontal deflections of the free end of the arch are given in Fig. 3 for cases where $\alpha = 0$.

Deflection Due to a Couple: A bending couple is an eccentric load acting on an arched cantilever in the plane of curvature. From Fig. 4, the bending moment for any section is

$$M = M_o + Vr(\cos\alpha - \cos\theta) + Hr(\sin\theta - \sin\alpha) \quad (10)$$

Substituting Equation 10 into Equations 1 and 2 and integrating gives the deflection equations,

$$Y = \frac{M_o r^2}{EI} K_y$$

and

$$X = \frac{M_o r^2}{EI} K_x$$

Curves in Fig. 4 are based on $\alpha = 0$ and represent deflection of the free end of the cantilever.

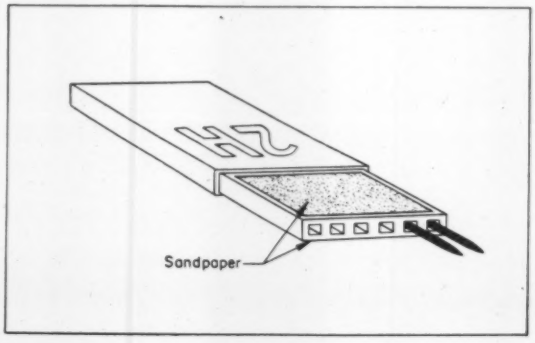
Tips and Techniques

Calculating Liquid Velocity

Four slide rule manipulations can simplify the calculation of liquid velocities in pipes. By setting the pipe size in inches on the *C* scale over 2.02 on the *D* scale, the velocity can be read directly in fps on the *A* scale opposite the value of *Q* in gpm on the *B* scale.—CLYDE S. SHIVE, *Domestic Pump and Manufacturing Corp., Shippensburg, Pa.*

Pencil Sharpener

Sandpaper for pointing pencils can be handled neatly by gluing it to the top and bottom of a lead box. When not in use the cover is replaced and sandpaper is not exposed.—FRANCIS J. ARSENAULT,



Esmond, R. I.

DESIGN ABSTRACTS

electrical

Microminiaturization Techniques

Martin J. Finkelstein, M-F Electronics

Engineering techniques and design principles used in producing module assemblies are covered. Problems of construction and their solutions are discussed, along with techniques of mounting components and soldering parts. How special operations for bending transistor lead wires can be eliminated by proper transistor mounting in the circuit board is shown.

IRE paper 4-1, from Second National Conference on Production Techniques, New York, June, 1958.

Impact of Transistors on Military Electronics Design

Andrew B. Jacobsen, Motorola Inc.

Advantages of the transistor in designing for reduced size and weight of military electronic packages are covered. Discussion includes shock and vibration problems, etched circuit techniques for component mounting and interconnection, and potted modular structures.

IRE paper 3-3, from Second National Conference on Production Techniques, New York, June, 1958.

Electroforming Millimetric Waveguide Components

A. J. Morrison, Mullard Radio Valve Co.

Manufacture of microwave components by conventional machining methods is often difficult and expensive. A process of electroforming on plastic is described which allows production of complex cavities simply and cheaply. The electroforming process is described in detail, and design techniques concerning the manufacture of a complex radar component are covered to illustrate process advantages.

IRE paper 2-4, from Second National Conference on Production Techniques, New York, June, 1958.

Pancake Motors Solve Space Problems

V. G. Honsinger, Allis-Chalmers Mfg. Co.

Pancake motors have been applied successfully to limited-space applications in industry. Basic forms of these motors are discussed, and their characteristics and applications are covered. Design features peculiar to the pancake motor are determined from equations which show how designs are achieved.

Allis-Chalmers Electrical Review, Vol. 23, No. 1, page 24.

Micromodules—Components And Materials Requirements

S. F. Danko and V. J. Kublin, U. S. Army Signal Engineering Laboratories

Present microminiaturization techniques are evaluated as the basis for a new micromodule concept. Application of this concept in advanced equipment is used to illustrate objectives of a miniaturization program currently under way for the Army. Deficiencies in certain materials areas which limit broad applicability of micromodules to electronics are discussed. Characteristics of microparts which require exploitation of new materials for basic circuit functions are described.

IRE paper 3-4, from Second National Conference on Production Techniques, New York, June, 1958.

Attitude Control System For Space Vehicles

Walter Haeussermann, Army Ballistic Missile Agency

Major requirements for a three-axis attitude control system are covered. Discussion of a proposed system and its characteristics is included, and feasible methods for attitude sensing are summarized.

ARS paper 642-58, from Semiannual Meeting, Los Angeles, June, 1958; 5 pp.

Designing With Polystrip Flat-Wire Cables

S. J. Stein and A. L. Pugh Jr., International Resistance Co.

This multiconductor flat cable offers a new approach to circuit miniaturization. Opportunities for creative circuit design and application, and techniques of soldering, branching, and shielding, are covered.

IRE paper 3-2, from Second National Conference on Production Techniques, New York, June, 1958.

materials

Engineering Properties of Commercial Titanium Alloys

H. V. Kinsey

Tabulated data concerning nominal chemical compositions and manufacturers' designations of commercially available titanium alloys. This is a correlation of all published data on physical, mechanical, and engi-

neering properties of these alloys with an indication of properties required by designers but for which data are not available.

NATO Report 100, "The Mechanical and Engineering Properties of Commercially Available Titanium Alloys," from the Fifth Meeting of Structures and Materials Panel, Oslo, Norway; 15 pp.

Techniques of Fabricating Commercial Titanium Alloys

R. I. Jaffee

Descriptions are given of various methods of fabricating titanium and its alloys. Techniques of finishing, joining, and machining are reviewed as well as physical and mechanical properties of current commercial alloys.

NATO Report 94, "Titanium Production Developments Including Metallurgy and Alloying," from the Fifth Meeting of Structures and Materials Panel, Oslo, Norway; 89 pp.

Primary Creep In Aircraft Design

B. B. Muvdi, The Martin Co.

Importance of the primary stage of creep in high-performance aircraft design stems from the fact that allowable deformations have to be limited to relatively small values consistent with requirements of high-speed flight. A method based on Kanter's exponential equation is proposed for predicting primary creep curves. While purely empirical, this technique has indicated good agreement with experimental results. A comparison is made between 17-7 PH stainless steel and 6A1-4V titanium alloy heat treated to 155,000 psi, in which material density is considered. Results indicate that the titanium alloy is superior.

SAE paper 46A, from SAE National Aeronautic Meeting, New York, April, 1958; 16 pp.

Corrosion and Oxidation Resistant Coatings for Metals

John V. Long, Solar Aircraft Co.

Development of coatings for metal protection at temperatures to 2400 F is discussed. Characteristics and effectiveness of some ceramic coatings are summarized from test results. Also included are methods of applying cermet coatings to carbon steel and cast iron, and an evaluation of diffused-aluminum coatings for various components.

SAE paper 46C, "Corrosion and Oxidation Resistant Coatings for Metals for Operation at Temperatures from 1000 F to 2400 F," from SAE National Aeronautic Meeting, April, 1958; 14 pp.

Structural Properties of High-Strength Sheet Steels

M. A. Melcon

Complexity of thermal problems in certain applications, and competition of other alloys, have forced some major developments in high-strength sheet steels. Structural properties and a brief strength-weight evaluation of steel, titanium, and aluminum are analyzed for purposes of orientation. Stainless steels covered include 420, 422, 422 M, AM 350, and 17-7 PH. Mechanical properties of these steels at room temperature and at elevated temperatures are covered.

NATO Report 101, "A Survey of the Structural Properties of Some High-Strength Sheet Steels," from the Fifth Meeting of Structures and Materials Panel, Oslo, Norway; 25 pp.

New Techniques in Potting, Encapsulating, and Molding

John L. Hull, Hull Corp.

Application and operation of a packaged, high-vacuum degassing and potting system for short pot-life resins are discussed. Techniques for high-volume encapsulating, and a new approach to economical molding of small, thermosetting plastic parts are also included. Production and testing data illustrate benefits to users and show designers how to take advantage of available equipment. Limitations and advantages of the encapsulating process through transfer techniques are described, and illustrations of typical components encapsulated by this technique are included.

IRE paper 4-5, "New Techniques in Potting, Encapsulating, and Small Parts Molding," from Second National Conference on Production Techniques, New York, June, 1958.

Use of Materials To 2000 F

Harry A. Pearl, Bell Aircraft Corp.

A general treatise on three major categories of materials: Metals of foil thickness, thermal insulations, and ceramics. How properties of materials must be evaluated in terms of specific designs is shown. A system developed at Bell for evaluating efficiency of a metal for use in various structures is explained by means of an example. Graphs indicate stress and temperature ranges for which materials are most efficient when a structure is based on a particular design configuration.

SAE paper 46B, from SAE National Aeronautic Meeting, New York, April, 1958; 13 pp.

mechanical

Balancing Heavy Shafts And Rotors

J. E. Petermann, Allis-Chalmers Mfg. Co.

Conditions of static and dynamic unbalance of shafts, and basic rules for determining and correcting unbalance, are covered. Step-by-step procedures for solving problems of unbalance are analyzed by vector methods.

Allis-Chalmers Electrical Review, Vol. 23, No. 1, page 30.

Automation of Floated-Gyro Drift Measurements

James G. Nelson, Minneapolis-Honeywell Regulator Co.

This paper describes the technique and equipment developed for auto mating measurement of single-axis, floated-gyro drift rate. Basic construction principles of single-axis floated gyros are described and illustrated. Sources and components of drift are discussed and defined. Random component of drift or standard deviation, which can be tested automatically, is shown to be a useful measure of gyro quality.

IRE paper 4-6, from Second National Conference on Production Techniques, New York, June, 1958.

Allis-Chalmers Electrical Review—Allis-Chalmers Mfg. Co., Milwaukee 1, Wis.

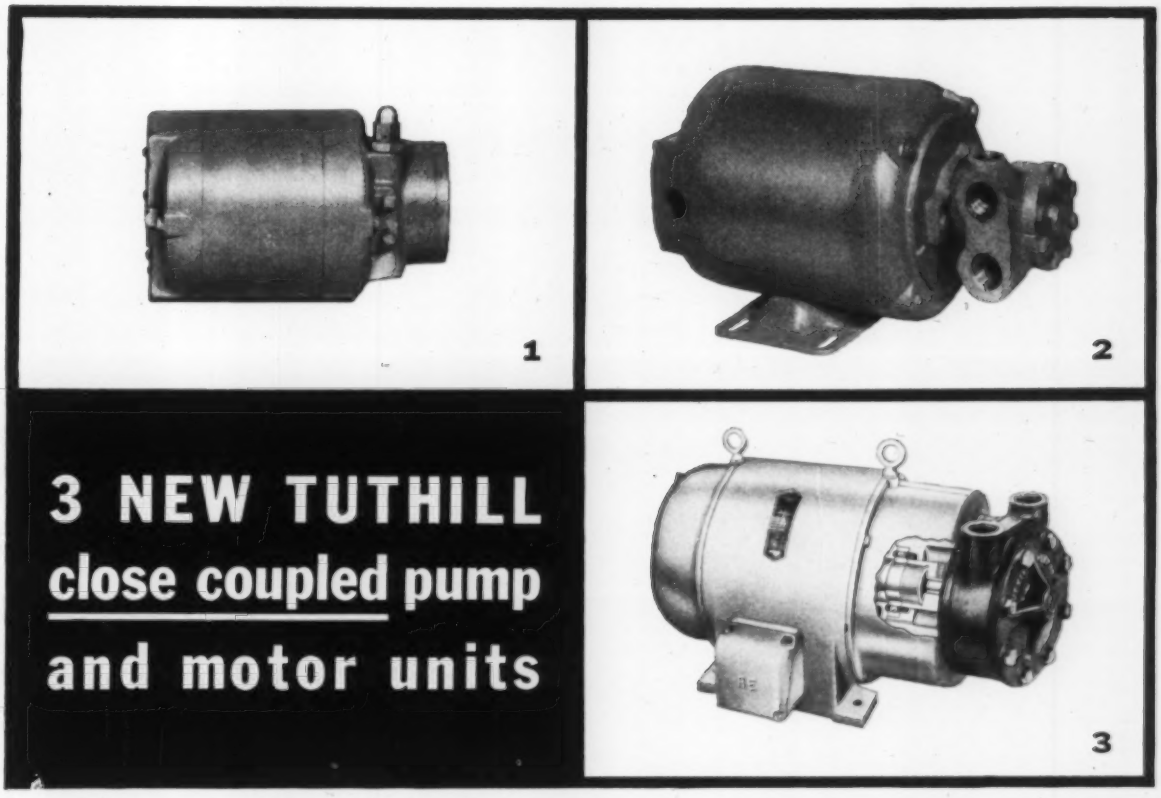
ARS—American Rocket Society, 500 Fifth Ave., New York 36, N. Y.

ASME—American Society of Mechanical Engineers, 29 West 39th St., New York 18, N. Y.; papers, 25 cents to members, 50 cents to nonmembers.

IRE—The Institute of Radio Engineers, 1 East 79th St., New York 21, N. Y.

NATO—North Atlantic Treaty Organization, National Advisory Committee for Aeronautics, 1512 H Street N.W., Washington 25, D. C.

SAE—Society of Automotive Engineers, Inc., 485 Lexington Ave., New York 17, N. Y.; papers, 50 cents to members, 75 cents to nonmembers.



Save space, Save weight, Cut costs

Now TUTHILL offers three pump and motor combinations developed specifically for applications where space or weight are at a premium. Furnished in a wide variety of sizes and styles, one of these combinations can provide savings in hydraulic, oil burning, lubrication or other services.

The small size of these combinations solves design problems. By reducing weight they cut shipping charges. The elimination of couplings, adapters and bases means lower costs. And even more important savings are often made through the simplification of installation procedures.

Available from Stock

A wide variety of combinations are available immediately from stock, in either large or small quantities.

For example, Number 1 above is TUTHILL'S famous POWERMITE—a combination in which pump and motor are incorporated in one unit which takes up no more space than a standard electric motor (the POWERMITE shown measures only 3⅞" x 7½").

Originally restricted to large quantity applications some POWERMITE models are now available from stock for small quantity orders. The unit shown is rated for 16 GPH at 350 PSI.

For other small quantity applications TUTHILL provides a complete selection of close coupled units with the pump mounted directly on the motor. Numbers 2 and 3 above are typical.

For applications, such as hydraulics which require smaller pumps, units such as Number 2 above provide outstanding advantages. Normally they can reduce space required for pump and motor by at least 6 inches, and cut weight by several pounds. Capacities range from 20 to 300 GPH. Pumps are available for pressures up to 1500 PSI.

Larger pump and motor combinations, such as Number 3 above, can be provided with capacities up to 50 GPM, for pressures up to 400 PSI.

If you are trying to put a pump and motor into a small space, TUTHILL has the answer. Write for details.

Tuthill Manufactures a Complete Line of Positive Displacement Rotary Pumps in Capacities From 1 to 200 GPM; for Pressures to 1500 PSI; Speeds to 3600 RPM.

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☐ Please forward complete information on TUTHILL close-coupled Pump and Motor Units for_____GPH at_____PSI.

☐ Please have your representative call.

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COMPANY_____

STREET_____

CITY_____

STATE_____

Circle 465 on Page 19

Helpful Literature
for Design Executives

For copies of any literature listed, circle Item Number on Yellow Card — page 19

Investment Cast Steels

Properties of eight stainless and four low alloy investment-cast steels are described in engineering data booklet. Steels are answer to a wide range of wear, corrosion, high temperature, and structural problems. Chemical compositions, specifications, and mechanical properties are among technical data given. 40 pages. Haynes Stellite Co., 30-20 Thomson Ave., Long Island City 1, N. Y. C

Circle 551 on Page 19

Speed Reducers

Speed reducers illustrated and described in Folder 4-102 may be foot or flange mounted and driven from above or below. Specifications for units with a wide range of speeds and ratios are presented. 4 pages. Janette Electric Mfg. Co., Morton Grove, Ill. J

Circle 552 on Page 19

Welding of Titanium

Handbook entitled "Titanium Welding Techniques" outlines the do's and don't's for successful welding of titanium. It covers fusion and resistance welding equipment and procedures, a study of typical weldments, and methods for evaluating weld quality. Many informative photos are included. 32 pages. Titanium Metals Corp. of America, 233 Broadway, New York 7, N. Y. D

Circle 553 on Page 19

Electronic Components

Standard, miniature, and subminiature pushbutton switches, including double-pole, solderless, and ultra-miniature types, are among electronic components described and illustrated in Catalog M-202. Test clips, binding posts, and a series of miniature rotary tap switches are also covered. 8 pages. Grayhill, Inc., 561 Hillgrove Ave., LaGrange, Ill. I

Circle 554 on Page 19

Self-Locking Nuts

Installation tips for a line of standard and miniature types of clinch nuts for avionic, electronic, and electrical equipment use are detailed in illustrated Design Manual 5803. Applications for the self-retaining, self-locking, shank type fastener are given. 18 pages. Elastic Stop Nut Corp. of America, 2330 Vauxhall Rd., Union, N. J. D

Circle 555 on Page 19

Vibration Isolation

Easy-to-use curve contained in Bulletin 901, Isolation Efficiency Curve determines the percentage of vibration isolation obtainable with any combination of static deflection and disturbing frequency in a flexibly mounted system. 4 pages. Lord Mfg. Co., Erie, Pa. F

Circle 556 on Page 19

Fusion Bond Finishes

Corvel fusion bond finishes—resin powders formulated for use with the Whirlclad finishing process—are described and pictured in Folder C-1. Method of application, advantages, and a finish selector chart are included. 4 pages. National Polymer Products, Inc., Reading, Pa. C

Circle 557 on Page 19

Fasteners

Characteristics and properties of different types of fasteners are found in illustrated booklet "Fastener Facts." Various types of bolts, cap, set, machine, and tapping screws; nuts; cotter pins; washers; rivets; and studs are covered. Related facts on each are presented. 20 pages. Lamson & Sessions Co., 1971 W. 85th St., Cleveland 2, Ohio. G

Circle 558 on Page 19

Tube Fittings & Tools

Specifications for extensive line of tube and pipe fittings, pressure hose and reusable couplings, valves, drain cocks, tube cutters, flaring tools, tube benders, air nozzles, drum faucets, push-pull controls, and fuel strainers are contained in illustrated Catalog 200. Imperial Brass Mfg. Co., 6300 W. Howard St., Chicago 31, Ill. J

Circle 559 on Page 19

Miniature Switches

Subminiature snap-action switches in a wide variety of configurations are covered in illustrated catalog. Operating characteristics, specifications, and application data are included. 8 pages. Electro-Snap Switch & Mfg. Co., 4232 Lake St., Chicago 24, Ill. J

Circle 560 on Page 19

Cast Aluminum

"Manufacturing Achievements in Molten Aluminum" is title of plastic-bound illustrated brochure which covers the growth of aluminum casting usage, plant facilities and services, aluminum permanent mold castings, aluminum and zinc die castings, trimming, secondary machining, custom finishing, and engineering analysis offered by the company. Typical products produced are shown. 28 pages. Monarch Aluminum Mfg. Co., 9205 Detroit Ave., Cleveland 2, Ohio. F

Circle 561 on Page 19

Socket Screws

Blue Devil Led-Lok socket cap screws for standard torque applications and Saf-Lok type for high torque applications are detailed in illustrated Folder L125. Led-Lok type seals against air, gas, oil, and water. Saf-Lok type withstands severe vibration. 4 pages. Safety Sockets Screw Co., 6501 N. Avondale Ave., Chicago, Ill. J

Circle 562 on Page 19

Remote Valve Controls

Design Manual 5811 on remote valve control systems includes data on flexible shafting, standardized valve operating gear for reach rods, and geared joints. A 300-degree swivel-geared joint is shown. Specifications of available units are included. 20 pages. Stow Mfg. Co., 11 Shear St., Binghamton, N. Y. D

Circle 563 on Page 19

Control Valves

VDP1 hydraulic direction control valves with a nominal rating of 12 gpm are covered in Catalog 1552. Pressure drop curves and drawings are shown for one, two, three, and four-spool models. Application data and cross-sectional diagrams are included for each type. 10 pages. Parker-Hannifin Corp., Parker Hydraulics Div., 17325 Euclid Ave., Cleveland 12, Ohio. M

Circle 564 on Page 19

Spring Engineering

"Manual of Spring Engineering" contains extensive technical data on spring production, specifications, materials, and design. Actually a textbook on the subject, the wire-bound, well-illustrated manual contains much technical data in table and chart form, 132 pages. United States Steel Corp., American Steel & Wire Div., Rockefeller Bldg., Cleveland 13, Ohio. F

Circle 565 on Page 19

Hose Clamps

Descriptions and illustrations of Sure-Tite, solid band, auto clamp, Strip-Tite, Noc-Out, and tubing clamps for industrial applications are contained on Data Sheet A-458. Sure-Tite stainless steel adjustable hose clamps are subject of Sheet P-458. 2 pages each. Wittek Mfg. Co., 4305 W. 24th Place, Chicago 23, Ill. J

Circle 566 on Page 19

Screws

Technical data on Phillips cross recessed head screws are contained in a reference booklet which will be revised annually. Information is given on all such screws in standard production, or pro-

Circle 466 on Page 19→

Better Saws . . .

BEGIN WITH SHARON QUALITY SAW STEELS

Sharon metallurgists have for the past decade concentrated on the development of better saw steels. As a result, they have established an industry-wide reputation for steels with a balance of toughness and hardness to absorb maximum punishment without fracturing or dulling.

It will pay you to contact your Sharon salesman and get the facts on these durable, edge-holding steels for saws or any cutting tool or implement.

SHARONSTEEL

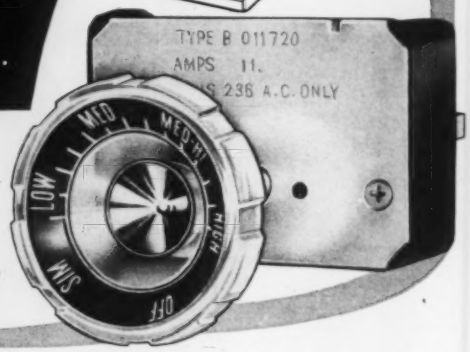
SHARON STEEL CORP.

SHARON, PENNSYLVANIA

THE Westinghouse RANGE CONTROL SWITCH

Chace THERMOSTATIC BIMETAL

Actuates Another Precision Product . . .



A Product of Westinghouse Electric Corp., Electric Appliance Service Div., Mansfield, Ohio

No more big "jumps" in electric range surface cooking heats. This Westinghouse Range Control Switch provides an infinite number of heats for all surface burners and is incorporated in the entire 1958 line of ranges. As many as four are used to control the average wattage delivered to each heater. This well-engineered and precision-manufactured product uses three thermostatic bimetal elements: the main operating element to open and close contacts; the differential element to introduce some temperature differential and thereby prevent contact fluttering; and the compensator element to give identical per cent inputs at all ambient temperatures.

We at Chace accept the heavy responsibility placed upon us by appliance manufacturers such as Westinghouse. For it is our duty—and our privilege—to provide dependable thermostatic bimetal for the countless actuating devices in the millions of appliances which help to make our lives safe, comfortable and worry-free. Thus these marvelous products can go to the far corners of the globe—and the automatic features actuated by Chace Thermostatic Bimetal will operate year after year with efficiency and a minimum of attention. In more than a third of a century as exclusive manufacturers of bimetal, we have learned that only a truly precision product can give completely reliable service.

So remember Chace when you design for protection of valuable equipment or for temperature actuation or indication. Dependable Chace Thermostatic Bimetal is available in over 30 types, in strip, coil or completely fabricated and assembled elements to your design. Write today for new 1958 booklet, "Successful Applications of Chace Thermostatic Bimetal", containing many pages of design data.

W. M. CHACE CO.
Thermostatic Bimetal
1616 BEARD AVE., DETROIT 9, MICH.

curable from standard tooling. Screw Research Association, 1015 Chestnut St., Philadelphia 7, Pa. E

Circle 567 on Page 19

Adjustable Closures

Snap-Tite adjustable closures which feature cam action for fast operation on low pressure and Turn-Tite lever handle closures for strong action on pressure sealing are described in illustrated folder. Available sizes and types are listed. Moeller Mfg. Co., Industrial Div., 2401 Durand Ave., Racine, Wis. K

Circle 568 on Page 19

Laminated Plastics

Grades of Synthane laminated plastics in rod and tube and sheet forms are listed with governmental agency specifications on Data Sheet 3585M. Nine specifications are given for each of many grades. 1 page. Synthane Corp., Oaks, Pa. E

Circle 569 on Page 19

Gearmotors

Five basic models of alternating current gearmotors, with a power range to meet specific applications, are described in illustrated Bulletin A58G. Engineering specifications are included. 4 pages Motoresearch Co., Racine, Wis. K

Circle 570 on Page 19

Powdered Metal Parts

Savings possible with powdered metal parts are outlined in illustrated folder. Parts can be produced with a specified porosity, special alloying ingredients, nonmetallic composition, friction surfaces, high temperature resistance, etc. Design pointers are included. 8 pages. Compacted Metals Corp., 99 Greenwood Ave., Waukegan, Ill. J

Circle 571 on Page 19

Stainless Steels

Various cold forming methods, machining, sawing, riveting, forging, annealing, and pickling of Enduro stainless steels are among subjects detailed in illustrated fabrication booklet. Recommended practices after fabrication, including grinding, etching, painting, cleaning, and passivation, are also covered. 36 pages. Republic Steel Corp., Republic Bldg., Cleveland 1, Ohio. F

Circle 572 on Page 19

Speed Reducers

Hy-Torq speed reducer, which operates on the epicyclic principle without gear train or worm gears, is described in illustrated folder. Wide range of ratios in single and double-stage units up to 5 hp is listed. 4 pages. Barr Mfg. Corp., 2790 W. Seventh Ave., Denver 4, Colo. K

Circle 573 on Page 19

Aluminum Alloy Bearings

Metallurgy, design, and service characteristics of aluminum alloy bearings are covered in a reprinted article by H. Y. Hunsicker. Performance characteristics and application data are included, along

Circle 467 on Page 19

with many photomicrographs and graphs. 118 pages. Aluminum Co. of America, Cleveland, Ohio. F

Circle 574 on Page 19

Wire-Wound Resistors

Encapsulated precision wire-wound resistors which feature stability, low temperature coefficient, and close tolerances, are described in illustrated Folder U-EB-3. Technical specs and dimensional schematics are among contents. 4 pages. Ultronix, Inc., 116 S. Bayshore Blvd., San Mateo, Calif. M

Circle 575 on Page 19

Drawing Instruments

Variety of sets of drawing instruments are illustrated and their contents listed in folder which gives prices. Instruments are made in Germany. 4 pages. Unitech Corp., 50 Colfax Ave., Clifton, N. J. D

Circle 576 on Page 19

Temperature Controls

Type C11 wide range temperature control for engine cooling systems and marine applications, and Type E32N indicating temperature control for ovens, baths, test chambers, molding machines, etc., are subject of technical literature. Specifications of both units are included. United Electric Controls Co., 79 School St., Watertown, Mass. B

Circle 577 on Page 19

Appliance Switches

Choice of actuators is offered with the Acro appliance switches, available in various ratings, terminals, and circuit arrangements. Technical details are given on data sheet. 2 pages. Robertshaw-Fulton Controls Co., Acro Div., Columbus 16, Ohio. G

Circle 578 on Page 19

Permanent Magnets

Stock permanent magnets, magnetizers, and demagnetizers are described in illustrated Catalog PR-19. Over 70 cast Alnico V and 30 sintered Alnico II magnets listed are used in many types of devices. 12 pages. Indiana Steel Products Co., Valparaiso, Ind. J

Circle 579 on Page 19

Air Cylinders

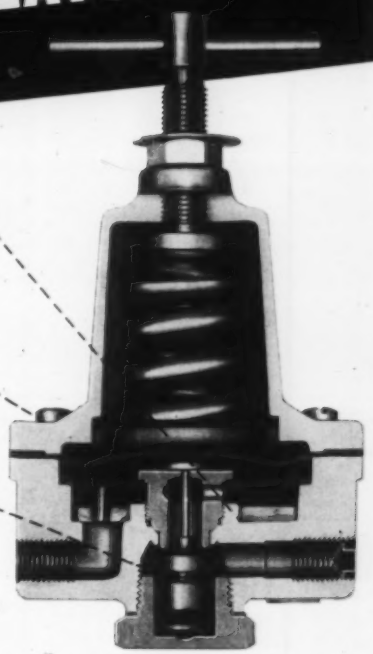
Nonrotating, 200-psi air cylinders are reviewed in illustrated Bulletin A-105K. Mounting data include schematic drawings for various models. Complete specifications and a cut-away view showing engineering details are included. 8 pages. Flick-Reedy Corp., Miller Fluid Power Div., 2040 N. Hawthorne Ave., Melrose Park, Ill. J

Circle 580 on Page 19

Circuit Breakers

Industrial molded-case circuit breakers with matching enclosures is subject of Bulletin GEA-6754. Information needed to select, specify, and order the equipment is included, along with a simplified guide for determining the proper ampere rating of breakers. Products are illus-

NEW... Norgren
WATER PRESSURE REGULATORS



LOW COST... Plus LONG, TROUBLE-FREE SERVICE

- The NEW Norgren Water Pressure Regulators provide accurate regulation of pressure even with widely fluctuating line pressure and rapidly varying flow. Line pressures up to 400 psi are reduced to working pressures up to 250 psi.
- All parts in contact with water are designed to give maximum protection against corrosion.
- For ¼", ⅜", ½", ¾" and 1" pipe sizes.

For complete information, call your nearby Norgren Representative listed in your telephone directory . . . or WRITE FACTORY FOR DESCRIPTIVE FORM 910

If it's Norgren...It's Dependable.

C. A. NORGREN CO.

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Circle 468 on Page 19

Looking for a Better Way

...to cut costs

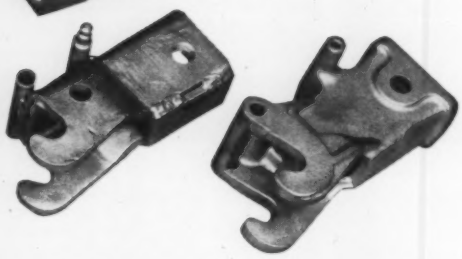
...improve appearance of your product?

How about Malleable?

Malleable Iron's outstanding characteristics—toughness, ductility, ease of machining—command your consideration when you search for better ways to produce your product or its components. Here are two more examples of simplification and cost reduction.

A tractor fuel tank support was formerly made up of 5 pieces. The Pearlitic Malleable casting saves 40% for the manufacturer . . . improves appearance 1000%!

This implement coupler now looks better as a standard malleable casting, and is produced at much lower cost. It was formerly an assembly of 4 pieces entailing 7 costly operations.



Examples similar to these are plentiful. But more and more items are *designed* for Malleable as engineers realize (or remember!) its many advantages. . . Have you seen our "Value Analysis" brochure? Write for your copy, today.

Consult a malleable foundry engineer at the drawing board stage.

Malleable FOUNDERS' SOCIETY

1800 Union Commerce Building Cleveland 14, Ohio

HELPFUL LITERATURE

trated. 28 pages. General Electric Co., 87 Whiting St., Plainville, Conn. B

Circle 581 on Page 19

Mercury Timer Relays

Hydrogen arc-quenched mercury timer relays with mercury-to-mercury contact are detailed in Engineering Specifications Bulletin 800 Rev. D. They are offered in different contact positions, contact actions, delays, and capacities. 6 pages. Durakool, Inc., Elkhart, Ind. J

Circle 582 on Page 19

Small Diameter Tubing

End uses of small diameter stainless steel, nickel, and nickel alloy tubing and company's facilities to produce fabricated and redrawn parts are covered in illustrated booklet. 20 pages. J. Bishop & Co., Malvern, Pa. E

Circle 583 on Page 19

Electronic Components

Basic technical data and prices are given for a complete listing of Eimac products in 1958 catalog. Covered are power amplifier klystrons, reflex klystrons, tetrodes, triodes, rectifiers, pulse modulators, sockets, and other accessory items. Eitel-McCullough, Inc., San Bruno, Calif. M

Circle 584 on Page 19

Plastic Products

Stocked plastic sheets, rods, tubes, films, and lay-flat tubings are listed in this catalog and price list. Comparative properties of acetate, acrylic, butyrate, Implex, Kel-F, Mylar, nylon, phenolic, polyethylene, polystyrene, high impact styrene, Teflon, and vinyl plastics in various forms are given. Available sizes, weights, colors, etc., are given. 64 pages. Cadillac Plastic & Chemical Co., 15111 Second Ave., Detroit 3, Mich. H

Circle 585 on Page 19

Reactive Metals Products

Products, facilities, and services of Nuclear Products Div. are illustrated and described in Data Memorandum 23. Products lists include control rods and channels or structurals for control rods and fuel element assemblies, fabricated from the reactive metals. 4 pages. Superior Tube Co., 1578 Germantown Ave., Norristown, Pa. E

Circle 586 on Page 19

Hose & Expansion Joints

Specifications of Rex-Weld corrugated, Rex-Tube convoluted, and Rex-Flex corrugated flexible metal hoses and Flexon corrugated expansion joints are included in illustrated Catalog 171. Design features and application data are also included. 8 pages. Flexonics Corp., 1322 S. Third Ave., Maywood, Ill. J

Circle 587 on Page 19

Circuit Breakers

Information on the use of current-limiting Cordon circuit breakers for short circuit protection on low voltage systems is given in illustrated Bulletin 5043-A. They have an interrupting rating of 100,-

000 amp. Applications, operational curves, and other technical data are included. 20 pages. I-T-E Circuit Breaker Co., Small Air Circuit Breaker Div., Philadelphia 30, Pa. C

Circle 588 on Page 19

Boron Nitride

Properties, advantages, and uses of easily-machined, impermeable boron nitride are outlined in technical bulletin. The ceramic material has good electrical and corrosion resistant properties up to 3000° F. Typical analyses and their properties are given. 4 pages. Carborundum Co., Box 337, Niagara Falls, N. Y. N

Circle 589 on Page 19

V-Belts

Constructions of Balanced Design Green Seal V-belts are described and illustrated in Bulletin S-5129. Five cross sections and standard lengths available are listed. 4 pages. Goodyear Tire & Rubber Co., Industrial Products Div., Akron 16, Ohio. F

Circle 590 on Page 19

Rotary Joints

Seamlex rotary joints for conveying steam, water, air, and other materials are described in Bulletin 5500-B. Construction, engineering features, and operating results are covered. Diagrams illustrate protection against leakage. 8 pages. Seamlex Co., 41-23 24th St., Long Island City 1, N. Y. D

Circle 591 on Page 19

Subminiature Terminals

Dimensions and performance data on over 200 types of subminiature Teflon terminals are given in Catalog SMT-2759. Stand-offs, feed-throughs, plugs, jacks, and many other types and their ratings and specs are included. 8 pages. Trinseel, Inc., 177 I. U. Willets Rd., Albertson, L. I., N. Y. D

Circle 592 on Page 19

Mill Regulator

Dual circuit VSMR mill regulator for precise regulation of line speed, voltage, and tension for all continuous process industries is subject of illustrated Bulletin K-2503. How one half automatically carries the full load in the event of tube failure in the other half is explained. 6 pages. Reliance Electric & Engineering Co., 24701 Euclid Ave., Cleveland 17, Ohio. F

Circle 593 on Page 19

Magnetic Disc Brake

Principle of operation and design features of the Style UH 70 Series magnetic disc brake are included in Specification Sheet 3202. Maximum torque available is from 10 to 75 lb-ft. Unit is suited for Class I, Group D hazardous locations. 2 pages. Stearns Electric Corp., Milwaukee 2, Wis. K

Circle 594 on Page 19

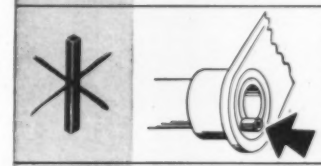
Blowers & Exhausters

Operating data, specifications, and performance curves for expanded line of

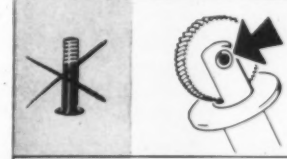
FASTENER PROBLEM

6 ways Rollpin simplifies fastening operations

REPLACING A GROOVED PIN . . . in this application, Rollpin serves as a stop pin in a ratchet wrench adaptor. With its light weight and high shear strength, Rollpin functions perfectly . . . cuts assembly costs.



REPLACING A KEY . . . Rollpin demonstrates its ability to do away with precision tolerances, in this heating system damper arm. Faster, cheaper and more satisfactory than previous assemblies.



REPLACING A RIVET SHAFT . . . Rollpin serves as an axle for the sparkwheel of a cigarette lighter. No riveting or threading necessary . . . faster assembly. Note flush, clean fit.

REPLACING A COTTER PIN . . . Rollpin assembly time is shorter, service life ten times longer. Vibration-proof flush fit. Easily removable.

REPLACING A SET SCREW . . . to fasten automobile brake handle a short length Rollpin is self-retained in the hand grip but can easily be driven into over-drilled hole in shaft for simple handle removal.

REPLACING A CLEVIS PIN . . . here Rollpin holds firmly in clevis, permits free action of moving member. Rollpin application shown is the plate of a home workshop tool.

WHERE CAN YOU USE THIS SIMPLE FASTENER?

Rollpin is the slotted tubular steel pin with chamfered ends that is cutting production and maintenance costs in every class of industry.

Drives easily into standard holes, compressing as driven. Spring action locks it in place—regardless of impact loading, stress reversals or severe vibration. Rollpin is readily removable and can be re-used in the same hole. Made in carbon steel, stainless steel and beryllium copper. Write for samples and information, ELASTIC STOP NUT CORPORATION OF AMERICA, 2330 Vauxhall Road, Dept. R49-64, Union, New Jersey.

ELASTIC STOP NUT CORPORATION OF AMERICA

Vauxhall Road, Dept. R49-64, Union, New Jersey.

ROLLPIN®

Circle 470 on Page 19

THIS NEW INDUSTRIAL ENGINE

See **Jeep 6** *quality designed for rugged duty*

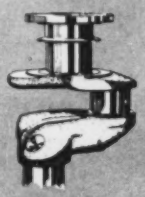
PISTONS

- FOUR RINGS . . . including a Hard Chrome Compression Ring and a Hard Chrome Steel Rail Oil Ring.
- NEW CONTROL BAND . . . reduces the possibility of piston slap and skirt collapse.
- ALUMINUM ALLOY PISTONS . . . are hand fitted for exact tolerance.

VALVES

- HARD FACED VALVES . . . of Stellite or Eatonite.
- VALVE INSERTS . . . of Stellite or Eatonite.
- POSITIVE VALVE ROTATORS . . . keep valves free and clean.

CRANK



- HEAVY DUTY BEARINGS . . . of Moraine Durex.
- FORGED CRANKSHAFT . . . statically and dynamically balanced.
- 100% COUNTER WEIGHTED . . . for smooth, quiet operation.

Heavy Duty Jeep 6 High Torque Power Curve

Maximum continuous duty torque peaks at 1200 rpm . . . and drops less than 8 per cent through its entire recommended continuous duty speed range. Continuous duty horsepower climbs from 33 to 65 through the same range. Maximum horsepower is 94 and maximum torque is 180 ft. lbs.

Here is a great 'Jeep' 6-cylinder engine . . . designed with quality features for the rugged power and dependability your customers expect! All standard accessories are available including a complete power unit.

Write for prices and specifications.

KAISER WILLYS MOTORS

WILLYS MOTORS, INC.
INDUSTRIAL ENGINE DEPARTMENT
TOLEDO, OHIO

three-lobe rotary industrial blowers and exhausters are presented in illustrated Bulletin 581. Line includes 12 high pressure aluminum and 12 high pressure cast iron models with capacities to 4000 cfm. 6 pages. Miehle-Goss-Dexter, Inc., Miehle-Dexter Div., 100 Fourth St., Racine, Wis. K

Circle 595 on Page 19

Valves

Valves are listed by function rather than by series in quick reference 1958 Digest Catalog. Information section presents fundamentals of pneumatics and various compressed air applications. Dimensions of all valves are included. 20 pages. Ross Operating Valve Co., 120 E. Golden Gate, Detroit 3, Mich. H

Circle 596 on Page 19

Capacitor Motors

Design features, dimensions, and frame sizes for line of integral horsepower, single-phase, capacitor motors are content of illustrated Bulletin 2401. Ratings range from ¾ to 5 hp. 4 pages. Fairbanks, Morse & Co., 600 S. Michigan Ave., Chicago 5, Ill. I

Circle 597 on Page 19

Chemical Slide Rule

Answers to many types of chemical engineering problems can be found on the Chem-Rule, subject of illustrated folder. Rule has scales for solving temperature, pressure, and solution concentration problems quickly and accurately. 4 pages. Frederick Post Co., 3650 N. Avondale Ave., Chicago 18, Ill. J

Circle 598 on Page 19

Weldments

Photos of typical weldments and machine bases made to specifications are contained in folder. They are made of steel, stainless steel, or aluminum. 4 pages. Littleford Bros., Inc., 453 E. Pearl St., Cincinnati 2, Ohio. G

Circle 599 on Page 19

Electrical Tapes

Where and how to use Scotch thermosetting adhesive and other electrical tapes with treated paper, acetate, polyester film, glass cloth, plastic, resin, and cloth backings is effectively treated in Brochure E-PCLC. Electrical resins, resin tapes, and splicing kits are also covered, as are facts on electrolytic corrosion. 32 pages. Minnesota Mining & Mfg. Co., 900 Bush Ave., St. Paul 6, Minn. J

Circle 600 on Page 19

Creep Rupture Tester

Company's new M-3 creep rupture tester, designed for small specimens or light loads, is described in folder. Floor space economy is pointed up. 4 pages. Arcweld Mfg. Co., Box 311, Grove City, Pa. G

Circle 601 on Page 19

Hydraulic Pumps & Motors

Line of Powermax hydraulic pumps and fluid motors described in Catalog 111 comprises seven pump models from 1.2

to 14.2 gpm capacity. Motors are furnished for continuous pressures to 1500 psi. Catalog gives complete data. 4 pages. Tuthill Pump Co., 953 E. 95th St., Chicago 19, Ill. J

Circle 602 on Page 19

FHP Motors & Reducers

Dimensional data and performance figures for fractional horsepower motors and gear reduction units covering load speeds to 20,000 rpm and torques from 1 oz-in. to 100 lb-in. are given in catalog. 18 pages. Rae Motor Corp., Racine, Wis. K

Circle 603 on Page 19

Hydraulic Pump-Motor

Technical bulletin on Model A hydraulic pump-motor units provides operating characteristics, performance curves, and overall dimensions. 2 pages. Oliver Tyrone Corp., Berry Hydraulics Div., Oliver Bldg., Pittsburgh 22, Pa. G

Circle 604 on Page 19

Modular Enclosures

Catalog 105 illustrates and specifies a number of basic frames in the Emcor modular enclosure system for housing instruments, electronic equipment, automation, and allied equipment. Component parts are also covered. 36 pages. Elgin Metalformers Corp., Elgin, Ill. J

Circle 605 on Page 19

Rotary Joints

Type C rotary joints for steam, water, oil, air, or gas service to temperatures of 450° F are descriptively covered in Catalog 310A. Sizes range from ½ to 3 in., right or left hand. 4 pages. Barco Mfg. Co., 500-530 N. Hough St., Barrington, Ill. J

Circle 606 on Page 19

Automatic Control Equipment

Automatic control equipment listed in Catalog 18 includes automatic transfer switches, magnetic contactors, remote control switches, program clocks, automatic reset timers, and cycle timers. Technical data are extensive. 64 pages. Zenith Electric Co., 152 W. Walton St., Chicago 10, Ill. J

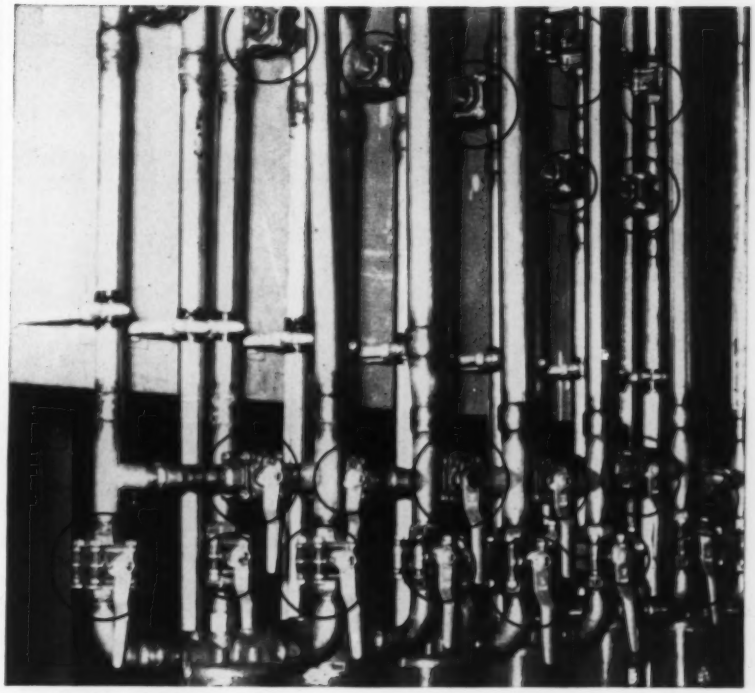
Circle 607 on Page 19

Integral HP Motors

Selection data on single and polyphase integral horsepower induction motors up to 20 hp are found in illustrated Bulletin 104. Motor construction is described and specifications of available models are presented. 8 pages. Request on company letterhead from Leland Electric Co., Box 1060, Dayton 1, Ohio. G

Instrument Components

Over 4000 precision instrument components that are available from stock are listed in Catalog 14. Gears, shafts, collars, differentials, and many others are included, along with much technical data and specifications. 128 pages. Available by request on company letterhead from PIC Design Corp., 477 Atlantic Ave., East Rockaway, L. I., N. Y. D

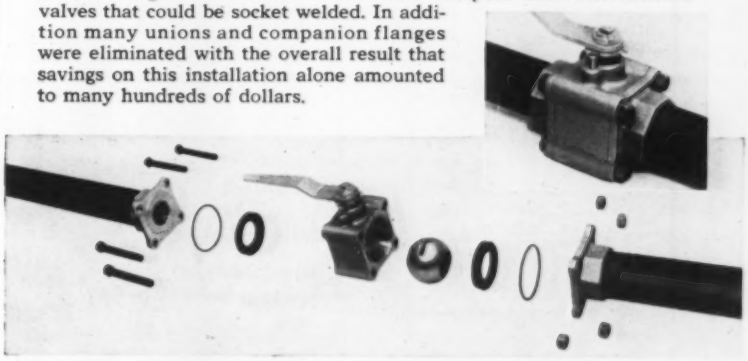


Only the ECON-O-"MISER" Ball Valve was able to solve this problem for PathéColor, Inc.

THE PROBLEM: To find a valve that would meet all of the following requirements:

1. Quick visual indication of position and quarter turn operation. 2. Excellent flow characteristics and positive shut-off. 3. The advantages of flange construction without the bulk and weight of conventional flanged valves. 4. Easy & quick disassembling for low cost maintenance. 5. The most compact and economical installation of Type 316 stainless steel valves possible.

SOLUTION: *Specifying* and *installing* Worcester's Econ-o-"miser" Ball Valve. In so doing PathéColor found a valve that provides a positive seal, a flanged construction much more compact than conventional valves that could be socket welded. In addition many unions and companion flanges were eliminated with the overall result that savings on this installation alone amounted to many hundreds of dollars.



Valves available, ¼"-2", in following standard materials*: Bronze, Aluminum Bronze, Aluminum, Carbon Steel and Types 303 and 316 Stainless Steel. Standard Seat and O-Ring materials*: Buna-N, Neoprene, and Teflon.

**Other materials available on request.*

For further information and descriptive literature write to:

WORCESTER VALVE CO., INC.

16 PARKER STREET • WORCESTER, MASS.

Circle 472 on Page 19

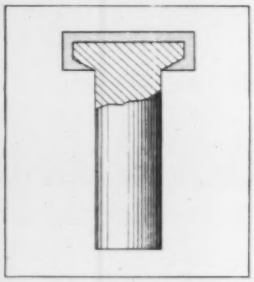
New Parts and Materials

Use Yellow Card, page 19, to obtain more information

Metal Fasteners

have plastic head

New Caplet fasteners consist of a metal rivet incorporating a plastic head which provides electrical insulation for over 5000 v. Standard sizes available are 1/16, 3/32, and 1/8-in. shank diam and any shank length in multiples of 1/32 in. Applications include use in electrical and electronic equipment requiring insulation of fastener from components, as an actuator knob such as



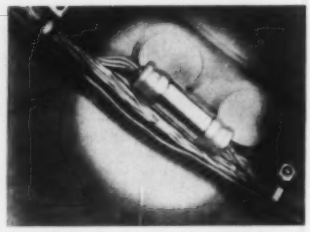
used on relays and switches, and for "feet" on desk equipment and appliances. **Pylon Co. Inc.**, Attleboro, Mass. B

Circle 608 on Page 19

Subminiature Relay

line-mounted unit resists vibration and shock

R100-2 subminiature power relay utilizes line-mounted termination, and incorporates as an integral part of the terminations quick-disconnect features which enable relay to be quickly mounted directly in line. Relay is hermetically sealed and eliminates contact contamination. It is resiliently cushioned and sealed against moisture and nuclear contamination, and resists vibration and shock. Relay becomes an integral part of line itself when mounted. It exceeds minimum requirements of MIL-R-6106C (tentative),



MIL-R-5757C, and MIL-R-25018. Relay line includes SPDT, DPDT, 3PDT, and 4PDT configurations rated at 2, 5, or 10 amp. **Electronic Specialty Co.**, 5121 San Fernando Rd., Los Angeles 39, Calif. L

Circle 609 on Page 19

Ceramic-Coated Wire

is rated for continuous operation to 1000 F

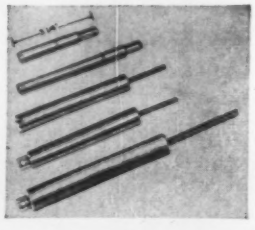
Ceramicite is a flexible insulated wire for use in military, aircraft, and industrial applications at continuous temperatures to 1000 F and intermittent exposure to 1700 F. Wire has excellent electrical characteristics and abrasion resistance, is extremely resistant to both thermal shock and mechanical vibration stress. Ceramicite is presently applied to solid conductors of nickel-clad copper or solid nickel. **Sequoia Wire & Cable Co.**, 2201 Bay Rd., Redwood City, Calif. M

Circle 610 on Page 19

Hydraulic Cylinder

miniature unit has stroke range from 1/2 to 6 in.

New miniature hydraulic cylinder



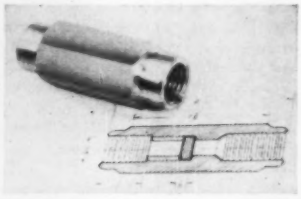
is available in a variety of sizes from 3/8 to 3/4 in. diam with stroke range from 1/2 to 6 in. Made of steel and aluminum, it is available in a wide range of anodized colors. Unit has many applications where a compact, miniature hydraulic cylinder is required, such as in hydraulic toys, and high-fidelity set manufacture. **Mo-Bar Hydraulic Sales Inc.**, Crystal Lake, Ill. I

Circle 611 on Page 19

Pressure Snubber

for pressures to 20,000 psi

New pressure snubber, capable of a maximum operating pressure of 20,000 psi, incorporates two 1/4-in. NPT female pipe connections. It is stainless steel, and can be used with low or high-viscosity oils, water or steam, and gases. Female connections eliminate need for a coupling or union where pressure instrument and snubber are to be assembled in a piping system having a male connection provided for pressure instrument. This feature re-



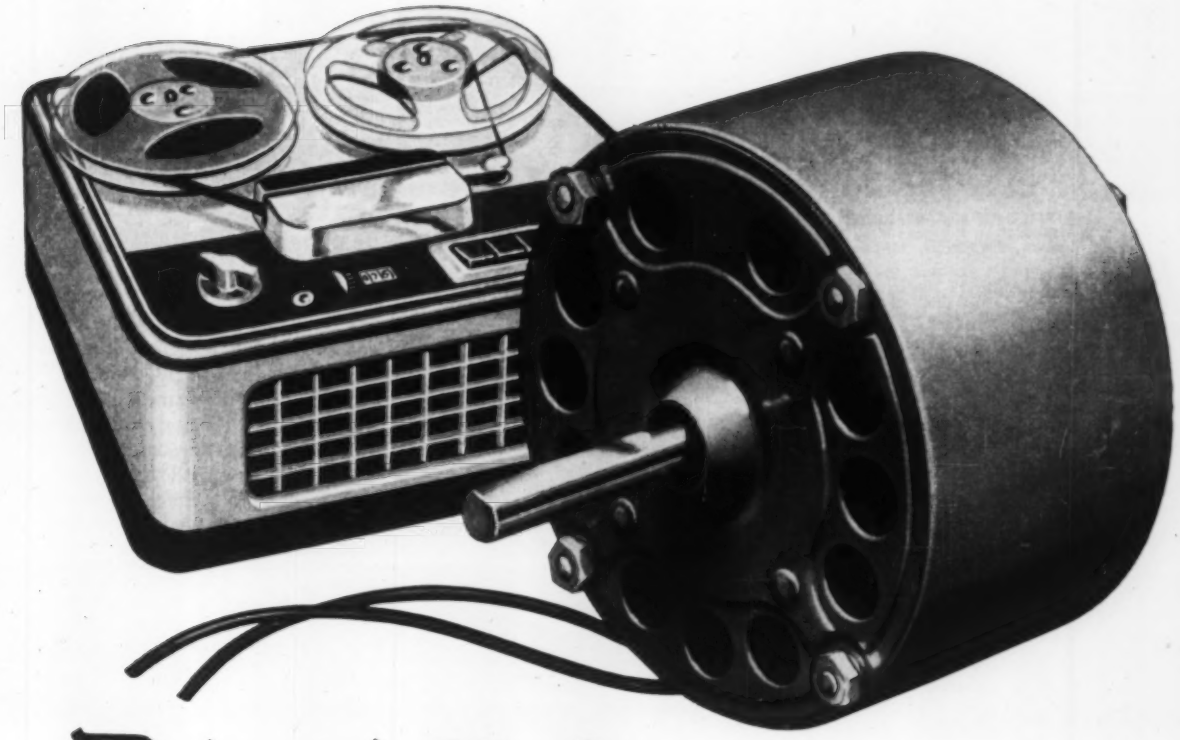
duces number of threaded connections and is of importance where noxious or toxic materials are present. **Chemiquip Co.**, 36 E. 10th St., New York 3, N. Y. D

Circle 612 on Page 19

Clutches and Brakes

operate within 1 millisec

New high-speed clutches and brakes, called Exactuators, operate within 1 millisec. Model C-400 clutch, il-



Redmond AL-4

Meets The Exacting Demands For Tape Recorders

Or Any Application Requiring An Economical, Compact, Lightweight, Quality Motor

The motor in a tape recorder and other high quality high fidelity equipment has to be smooth-running and whisper-quiet in operation. It must meet all "wow and flutter" specifications, and give years of trouble-free service. That is why leading manufacturers in this industry are now using thousands upon thousands of Redmond AL-4 MicroMotors.

The AL-4 is designed for a wide variety of applications, or it can be tailor-made for specific requirements. It is designed and styled to meet the modern demands for motors that are smaller and lighter, and yet have increased output. Besides tape recorders, it is widely used for portable washers, kitchen ventilators, ice crushers, fans, and dozens of other applications.

This modern motor can save money on a host of applications where economy is a factor and yet high quality is needed.

There is a Redmond sales engineer in your area who wants to help you adapt the AL-4 to your motor needs. Write, telephone, or wire us at Owosso, and we will have him contact you at once.

SEND FOR COMPLETE PERFORMANCE DATA

For the complete story on the new AL-4 motor—dimensions, performance, operational data, and suggested applications—write for the "AL-4 Bulletin."

The Standard of Dependability

Redmond

COMPANY, INC.

OWOSSO, MICHIGAN

ADVERTISED IN The Saturday Evening POST

REDMOND

THE BIG NAME IN SMALL MOTORS

Circle 473 on Page 19

MORE THAN 8000 STANDARD SPECIFICATIONS have been established by Judson L. Thomson Mfg. Co. for the five basic types of rivets: semi-tubular, deep-drilled, bifurcated (split), outside prong, and shouldered.

Seventeen Key Questions Simplify Value Analysis of Fasteners

By KENNETH E. JOY, General Sales Mgr.
Judson L. Thomson Manufacturing Co.

In approaching the problem of selecting fasteners that provide the greatest utility per unit of cost, it pays to be completely objective. Playing favorites or rejecting the old for the new can often prove costly. An unbiased approach to the analysis of fasteners, however, can slow down a project unless you have a system for quickly evaluating the many possible alternatives.

Such a system must have a starting point. May I suggest rivets as the logical start? There are two reasons why. As cold-formed fasteners, mass-produced at rates ranging from 75 to 400 a minute, rivets cost less than most other fasteners. Machine-set at rates as high as 180 a minute, they keep assembly costs at a minimum.

You can simplify the evaluation of rivets by answering the following seventeen questions:

1. Have you considered rivets for all assemblies that call for permanent fastening?
2. Where welding is now being used, can rivets plus gaskets or sealants provide comparable air tightness or water tightness at lower cost?
3. Where stapling is being used, can the heads of rivets add decoration or utility at little or no extra cost?
4. Where stitching is being used, can rivets replace or supplement it for greater strength?
5. Can rivets replace expensive removable fasteners where assembly is not absolutely essential?
6. Can self-piercing rivets — deep-drilled or bifurcated (split) — eliminate the cost of drilling or punching holes in the material to be assembled?
7. Can the addition of caps or burrs (washers) under the clinch of rivets permit their use on brittle or easily torn materials now fastened or joined a more expensive way?
8. Can the use of pneumatic or hydraulic rivet-setting machines which control impact allow the use of rivets for assembling fragile materials?
9. Can a change in assembly design provide access for machine-set rivets to replace more costly fasteners?
10. Can a change in assembly sequence introduce the speed and economy of riveting?
11. Can special cold-formed rivets replace more costly parts as pivots, contacts, stud followers and the like?

If the above questions lead to the decision that you can switch from other fasteners to rivets, the following questions will help you evaluate sources of rivets.

12. Does the rivet manufacturer make all kinds of rivets to give you complete freedom of choice?
13. How many standard specifications does the rivet manufacturer offer to lessen the possibility of more costly specials?
14. When special rivets are necessary does the manufacturer have experienced engineers who can solve new problems fast?
15. Does the rivet manufacturer also make machines to assure trouble-free assembly at lowest cost?
16. Does the supplier concentrate his engineering, production and quality control talent in one plant for expediting delivery of top quality rivets?
17. Does the supplier stock adequate supplies of most-wanted standard rivets in conveniently located points?

Free "Fastener Fact File"

This new manual of rivet and rivet setting machines provides complete information needed for efficient value analysis of fasteners.

Write Judson L. Thomson Mfg. Co., Dept. B, Waltham 54, Massachusetts.

JUDSON L. THOMSON MFG. CO., WALTHAM 54, MASS.

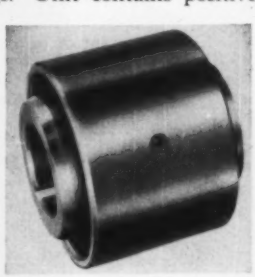
lustrated, features engagement and release times of less than 1 millisec with full torque of 30 oz-in. at 12 v dc input. Torque output is linear with respect to voltage or current input, and unit operates on as little as 1 v. It is suited for operation with transistors because of low voltage required and high efficiency of energy transfer. Exactuators can be used in clutch-brake combinations, contrarotation clutches, and double-speed clutches. Applications include tape and film feeds, spindle valves, stepping switches, counters, and other motion-controlled devices. Other applications exists in the fields of missiles, telemetry, automation, and control instrumentation. **Norman Hardy Associates**, P. O. Box 97, Wyncote, Pa. E

Circle 613 on Page 19

Flexible Coupling

of one-piece, continuous-sleeve construction

Series GC coupling is composed of only seven major components: two identical internal hubs, two lube-retaining rings, two spring-steel snap rings, and one continuous external sleeve in which parts are housed. One-piece, continuous-sleeve construction permits rapid assembly and disassembly of unit. Combination of fully crowned gear tooth with one-piece sleeve construction permits more torque capacity in less axial and circumferential space than required by other couplings. Unit contains positive hub



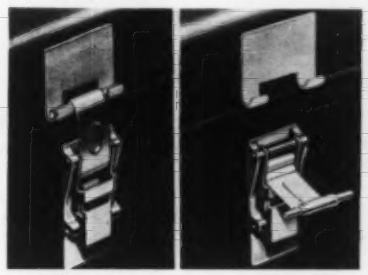
seals and accommodates shaft angular misalignment capacities to 3 deg. **Mechanical Power Transmission Div., Zurn Industries Inc.,** 1801 Pittsburgh Ave., Erie, Pa. F

Circle 614 on Page 19

Toggle Tension Latch

is miniature, lightweight closure

Model 30L miniaturized toggle tension latch is for use on airborne equipment boxes and similar closures requiring minimum latch clearance and light weight. Latch requires only 3/16-in. envelope for engagement and take-up, and has ultimate strength of 150 lb. Un-



usually shallow envelope permits almost face-to-face storage of equipment. The cam-action latch is actuated by a lift-lever and is permanently mounted by aluminum spot-welding. Provision is made for a safety wire. **Camloc Fastener Corp.,** 37 Spring Valley Rd., Paramus, N. J. D

Circle 615 on Page 19

High-Temperature Alloys

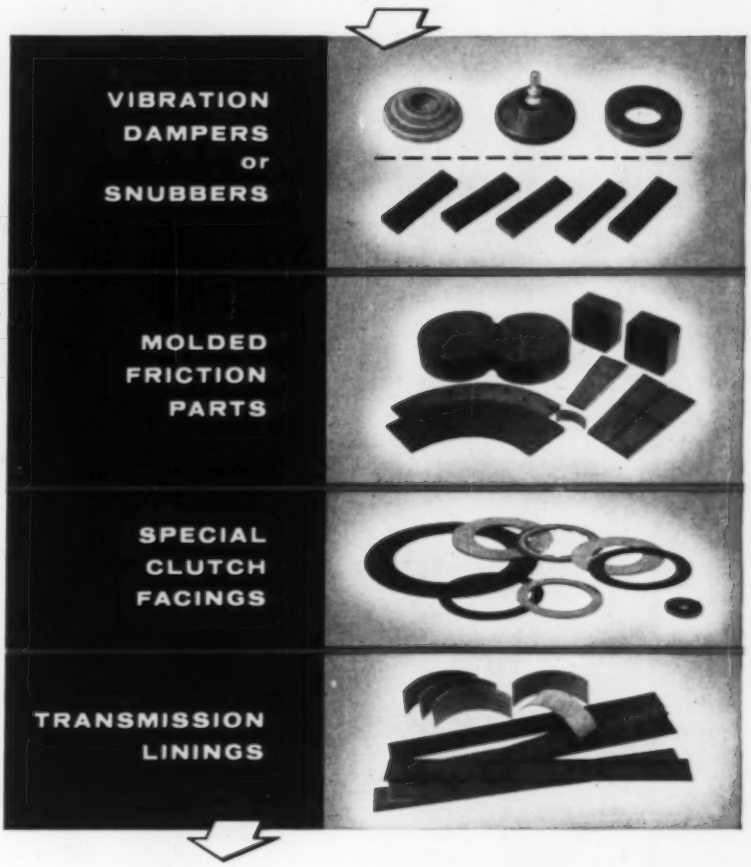
for applications requiring high strength

Two new high-temperature alloys, designated D-979 and AF-71, are available in billets, bars, sheet, wire, and forgings. Both alloys are furnished at present in experimental quantities on a developmental basis. Applications include jet aircraft engines and gas turbines, rocket and ram-jet engine components, automotive gas-turbine blades and wheels, and steam turbine and steam plant components. D-979, a nickel-chromium-based material designed for applications requiring high strength at temperatures to 1600 F, offers excellent tensile and creep-rupture properties. Alloy AF-71 is an iron-chromium-manganese

let **WORLD BESTOS**

help you

in the design and production of



● World Bestos offers you more than 30 years' engineering and manufacturing experience in the producion of molded friction parts. Chances are our immense resources and facilities can supply you with molded parts and friction components—to meet your requirements—at a savings in both time and money.

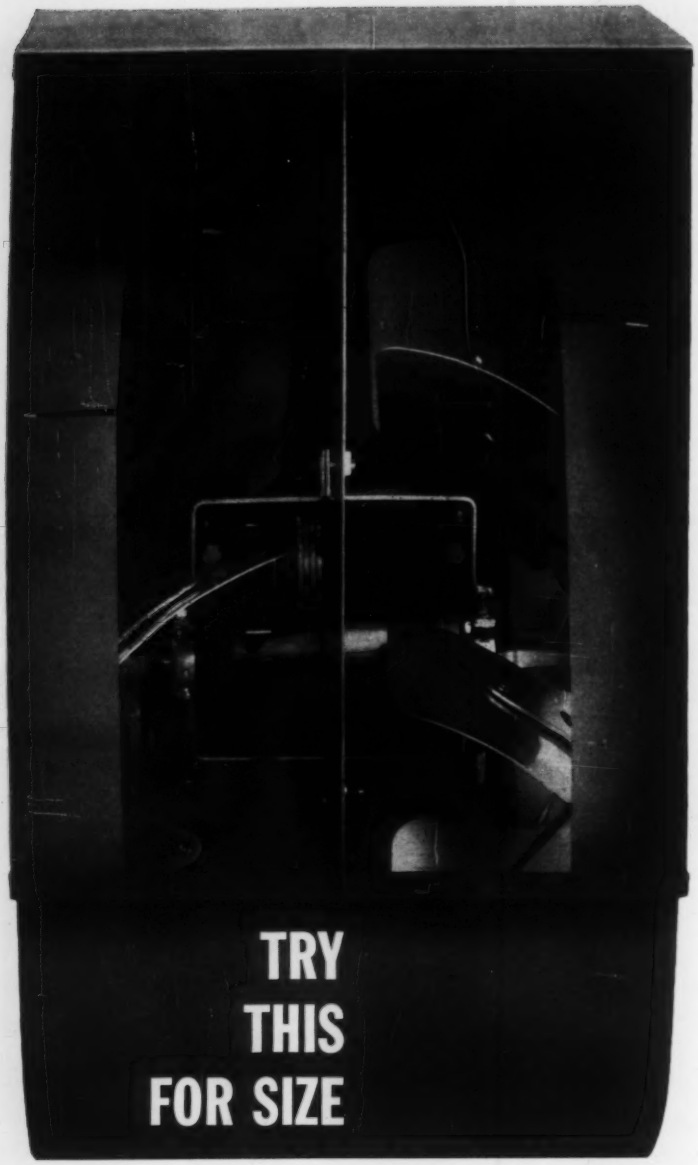
● Send your blueprints (or samples) for prices and delivery information to WORLD BESTOS, Industrial Products Section, New Castle, Ind., Phone: 2360. Write for free illustrated folder.

WORLD BESTOS NEW CASTLE, INDIANA

DIVISION OF THE Firestone TIRE & RUBBER COMPANY

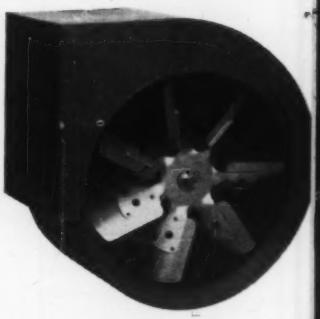
Industrial and Automotive Brake Blocks and Linings • Transmission Linings • Special Clutch Facings • Vibration Controls • Sheet Packing

Circle 475 on Page 19



TRY THIS FOR SIZE

IT'S THE GREAT NEW TORRINGTON MIXED-FLOW RADIAX ▌ 6 SIZES FROM 300 TO 3000 CFM ▌ SAVINGS UP TO $10 PER UNIT ▌ SIZE, WEIGHT AND MOTOR ECONOMY ▌ PLUS TORRINGTON REPUTATION ▌ FULL DETAILS AND ENGINEERING SERVICE ON REQUEST



IN YOUR '59 DESIGNS

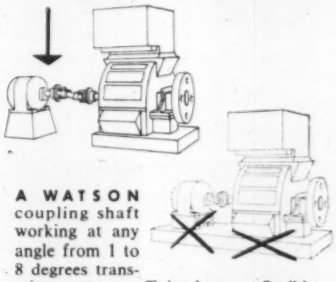
THE TORRINGTON MANUFACTURING COMPANY

TORRINGTON, CONNECTICUT • VAN NUYS, CALIFORNIA • OAKVILLE, ONTARIO

Circle 476 on Page 19

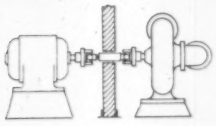
WATSON COUPLINGS Engineering Notes

How to Eliminate the Cost and Problems of Critical Alignment



A WATSON coupling shaft working at any angle from 1 to 8 degrees transmits power as efficiently as a flexible coupling, yet offers substantial savings in design engineering time and installation cost. Angles up to 20 degrees can be handled (depending on RPM). No painstaking axial alignment is required; simple, low-cost concrete foundations poured on the site replace costly unit base plates.

In addition to substantial savings in engineering design and installation time and cost, the use of WATSON coupling shafts offers:



WIDEST LATITUDE IN LOCATION of driving and driven elements for best utilization of space, distribution of weight, isolation of motor or engine, provision for maintenance or working space.

PROVISION FOR RELATIVE MOVEMENT between driving and driven elements, either intentional or as a result of structural deflection or foundation shifts.

WATSON Coupling Shafts are promptly available in 9 sizes, 10 to 800 h.p., for speeds to 4,000 r.p.m. and more. Why not get the facts — now. 8-page Engineering Data Bulletin F-11 is yours for the asking; please address Dept. J-6.

WATSON **H. S. WATSON COMPANY**

1316 - 67TH ST., EMERYVILLE 8, CALIF.
1606 LASKEY ROAD, TOLEDO 12, OHIO 4

Circle 477 on Page 19

material with low strategic alloy content, but which is almost as strong at 1500 F as other superalloys containing 40 to 50 per cent cobalt. It has excellent creep-rupture properties in the 1000 to 1500 F range. **Allegheny Ludlum Steel Corp.**, Henry W. Oliver Bldg., Pittsburgh 22, Pa. F

Circle 616 on Page 19

Panel Display Light

is miniature, transistorized unit

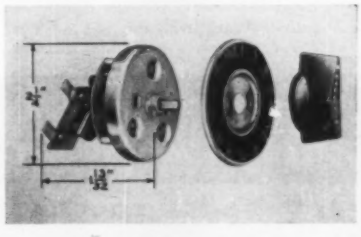
New panel display light, designated Mini-Lite, is a transistorized unit which measures only ½ in. diam and 1¼ in. long. Construction of the light includes a cylindrical black anodized aluminum body, standard NE-2E neon lamp at one end, and connections for A-MP series 53 taper pins at the other. Inside is a self-contained transistor circuit that requires 3.0-v signal to control light. Mounting requires only a ⅜-in. panel hole without keying. Lamp circuit requires 200 v dc at 0.5 ma. **Transistor Electronics Corp.**, 3357 Republic Ave., Minneapolis 26, Minn. J

Circle 617 on Page 19

Time Switch

small unit is rated 15 amp, 125 v ac

Mark-Time switch is for use on a wide variety of domestic and industrial appliances. When knob is turned to the left, it becomes a snap switch; turning knob to right, it



NEW LIQUID LOCKS SCREWS

Tumbling screws with "Liquid Lock Washer"
In just two minutes...
MAKE 20,000 LOCK SCREWS
OUT OF ORDINARY SCREWS
...and save $400!
Loctite-coated screws store for days... lock when assembled

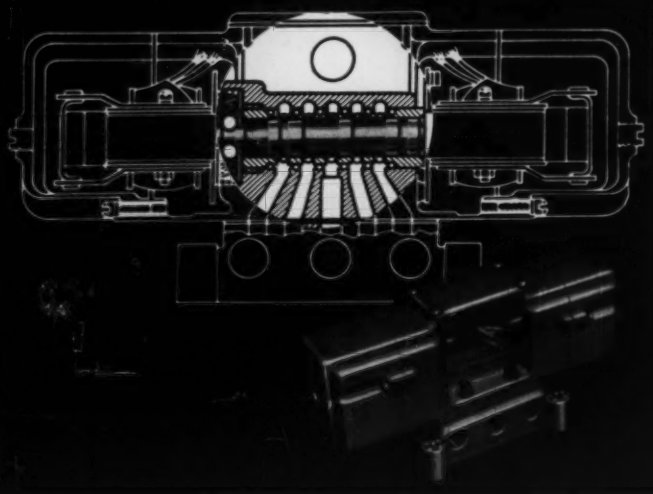
Loctite is the liquid lock that makes any threaded part self-locking. Loctite converts automatically to a tough, heat and oil-resistant plastic seal when confined between engaged threads. Locking action develops over the entire contact area, providing unequalled resistance to vibration. No heat... no mixing... not sticky.

Whether you use 20 or 20,000, you can get savings of up to 70% using Loctite and ordinary fasteners to replace more costly mechanical lock fasteners. For product reliability at lowered production cost, send for complete information on Loctite.

LOCTITE® SEALANT
AMERICAN SEALANTS COMPANY
111 Woodbine St., Hartford 6, Conn.
In Canada: J. S. Parkes & Co., Ltd., Montreal

Circle 478 on Page 19

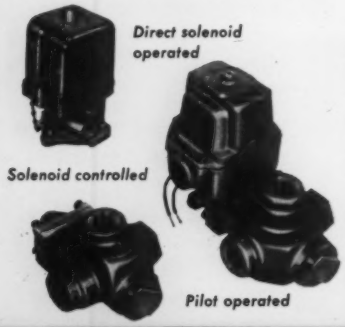
It's the air valve with the floating sleeve-lapped spool design



50 million cycles without a sign of wear!

This is not just a claim, it's a fact! And Numatics has the verified case histories to prove it . . . cases where Numatics SA Series valves are still performing like new after well over 50 million operations. *And not on a test bench under ideal conditions,* either, but out in the field on high speed welding guns, punch press scrap choppers, high speed packaging machines and other actual installations.

With the floating sleeve-lapped spool you can expect *and get* this kind of performance from every Numatics valve, because the spool has no seals or packers to wear out . . . it floats on a fluid film, never contacts the sleeve wall. The sleeve floats, too, on O-rings which isolate it from the valve body. Both spool and sleeve, what's more, are specially heat treated stainless steel, close-tolerance finished to minimize friction. In a nutshell, Numatics valves are designed and built to give you longer, more trouble-free life than is possible with ordinary air valves. Want a catalog? Send for it!



LOOK TO NUMATICS FOR LINE VALVES, TOO...

Numatics offers a complete *line of high speed, heavy duty 2-and 3-way in-line valves . . . valves you can depend on for top performance, long life, minimum maintenance and applications unlimited. And we'd like to* prove *it! May our representative call on you?*

NUMATICS, Inc. HIGHLAND, MICHIGAN

SALES REPRESENTATIVES FROM COAST TO COAST

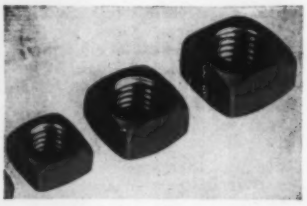
becomes a time switch. Unit is available with bell which provides clear, resonant tone at end of preset time period. Switch is rated 15 amp, 125 v ac, and is supplied with stationary male terminals for solderless connectors. **M. H. Rhodes Inc.,** Hartford 6, Conn. B

Circle 618 on Page 19

Square Nuts

are double chamfered and double countersunk

New cold-formed square nuts, available in standard regular dimensions, are double chamfered and double countersunk, permitting either end to be used as a seating face. Hole is accurately centered and faces are smooth. Corners will not dig into



or mar contacting surfaces, allowing tightening torque to be uniformly distributed over entire bearing surface. Threads are square with the face and held to Class 2B tolerances. All edges are free from burrs and corners are slightly rounded for quick application of wrench. Nuts exceed by 50 per cent the strength requirements in ASTM-A-307 standards. **National Machine Products Co.,** Utica, Mich. H

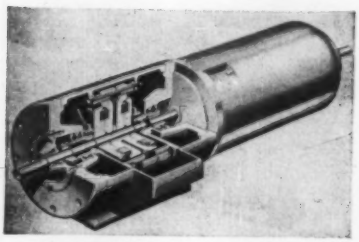
Circle 619 on Page 19

Adjustable-Speed Drive

uses constant-speed motors

Marvex adjustable-speed drive, using constant-speed motors, is available in four dripproof models in six different sizes. Unit is a controlled-slip, eddy-current coupling combined with various motors to serve as adjustable-speed gearmotor, adjustable-speed motor, and special unit for integral mounting of speed reducers. Drive handles motors up to 150 hp at 1750 rpm. Maximum torque transmittal is 450 lb-ft. Drive eliminates costly motor-generator sets, gives gear drives a Class I rating by eliminating shock load factors, and eliminates

Circle 479 on Page 19



use of mechanical clutches. Applications include drive for fans, pumps, compressors, extrusion machines, punch presses, cranes, winches, tube draw benches, rolling mills, winding and reeling machinery, conveyors, printing machinery, centrifugal casting machines, and machines requiring rapid and frequent reversal. **Cone-Drive Gears, Div., Michigan Tool Co.**, 7171 E. McNichols Rd., Detroit 12, Mich. H

Circle 620 on Page 19

Potting Compound

has temperature range from −80 to 450 F

Helix potting compound P-460 is a 100 per cent epoxy resin compound which has good dielectric strength and low water absorption factor, making it suitable for encapsulating electrical components vulnerable to moisture and fungus. It offers extreme hardness and temperature range from −80 to 450 F. Compound is poured cold, cures in about 2 hr at room temperature, and has less than 1 per cent cure shrinkage. **Carl H. Biggs Co.**, Dept. 360, 2255 Barry Ave., Los Angeles 63, Calif. L

Circle 621 on Page 19

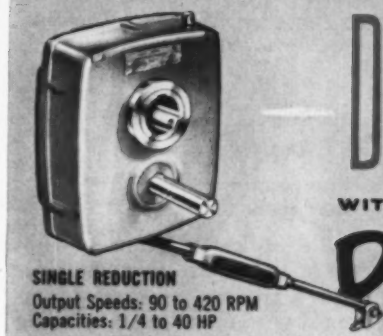
Bevel Gears

provide high load capacity

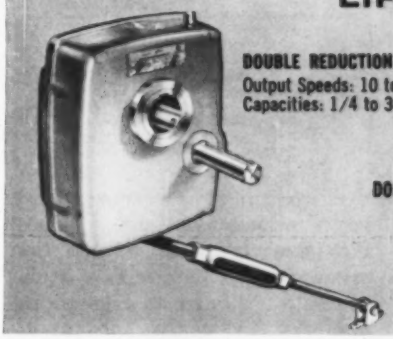
New FMS full-fillet, multicontact, spheroid bevel gears provide high load capacity and smooth, quiet ac-

NOW AVAILABLE FROM STOCK

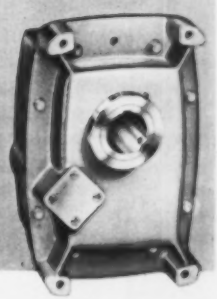
FOOTE BROS. SHAFT MOUNTED DRIVES WITH Duti-Rated® LIFETIME GEARING*



SINGLE REDUCTION
Output Speeds: 90 to 420 RPM
Capacities: 1/4 to 40 HP



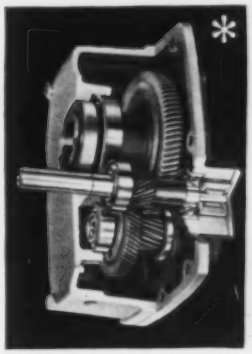
DOUBLE REDUCTION
Output Speeds: 10 to 160 RPM
Capacities: 1/4 to 30 HP



DOUBLE REDUCTION FLANGE MOUNT
Output Speeds: 10 to 135 RPM
Capacities: 1 to 7 HP

Foote Bros. Shaft Mounted Drives offer more efficient, more economical, power transmission. They incorporate exclusive Duti-Rated Lifetime Gearing — the high hardness, balanced design, premium quality gearing that combines greater load carrying capacity with long service life.

Used with standard V-Belts and Sheaves, Foote Bros. Shaft Mounted Drives will provide virtually any output speed you may require. Quick, easy installation on driven shafts with diameters from 15/16" to 3-7/16" saves time, labor . . . eliminates need for reducer mounting, couplings, and adjustable motor mount. Built-in Backstop to prevent reverse rotation, Automatic Overload Release Torque Arm, Variable Pulley, are available as optional equipment.



The complete Foote Bros. Shaft Mounted Drive line is made in accordance with all applicable AGMA Standards.

Write for NEW SHAFT MOUNTED DRIVE CATALOG

This Trademark Stands for the Finest Industrial Gearing Made

T.M. REG. U.S. PATENT OFFICE

FOOTE BROS.
Better Power Transmission Through Better Gears

FOOTE BROS. GEAR AND MACHINE CORPORATION
4567 S. Western Boulevard • Chicago 9, Illinois

Circle 480 on Page 19

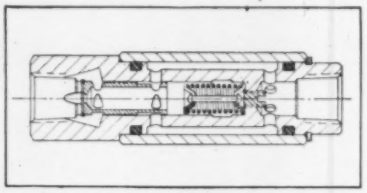
tion. Class A gears are suitable for the majority of industrial applications. Class AA gears meet exacting requirements for precise gearing as well as for load-carrying ability. Both classes operate equally well in either direction of rotation. Backlash is closely controlled and thrust loads are at a minimum. All gears of the same part number are interchangeable. **American Transmission Corp.**, 575 Bloomfield Ave., Verona, N. J. D

Circle 622 on Page 19

Flow Regulator

incorporates free-reverse flow check

New fixed-flow regulator incorporates a free-reverse flow check for use as a pressure-compensated, constant-flow regulator in oil-hydraulic circuits where reverse flow of a



larger volume than the regulated flow must be obtained at a low pressure drop. Reverse flow is uncontrolled. **Waterman Engineering Co.**, 725 Custer Ave., Evanston, Ill. J

Circle 623 on Page 19

Low-Expansion Ceramics

for high-temperature uses

E-313 and E-105 low-expansion ceramics are manufactured for high-temperature uses where material expansion is critical. The lithium-aluminum-silicate ceramics are formed in a variety of shapes by slip casting, hydraulic pressing, and extrusion. E-313 has a zero coefficient of expansion and can be used continually at temperatures to 1830 F; short-term temperature peaks can go up to 2100 F. With a flexural strength of 8000 psi, the ceramic is gas tight and has specific gravity of 2.3. Good mechanical strength, coupled with zero expansion, provides, excellent thermal shock resistance. E-105 ceramic has flexural strength of 2000 psi and total porosity of 20 per cent.

Y MOTOR OFFERS ADAPTABILITY

This compact 4-pole shaded pole induction motor gives you a wide choice of horsepower, voltages, frequencies, starting torque, mounting provisions and other modifications. Standard models have horsepower ratings from 1/30 to 1/200 hp; free speed 1700 rpm; load speeds 1400 to 1700 rpm; 115v, 60 cycle, CW or CCW; high or low starting torque. Mounting provisions are 2 or 4 stud, flat strap, or saddle strap. Modifications include end or side ventilations; internal fan. Other voltages and frequencies are available. Typical applications are for vending machines, fans, aquarium pumps, etc.

The Y Motor is just one of many models in the comprehensive line of Heinze Sub-Fractional Horsepower Motors and Blowers. Send us your product and specifications. Heinze Engineers will adapt a motor at no obligation. Or write for catalog.

HEINZE ELECTRIC COMPANY
685 Lawrence St., Lowell, Mass.

Sub-Fractional Horsepower Motors and Blowers

Circle 481 on Page 19

IT'S NOT "ALL IN THE MIND"...

. . . at BOEHME'S your ideas are quickly and efficiently developed and produced into precision engineered products that meet today's competitive demands.

BOEHME services run the gamut from fine pitch precision gears, to electrical, electromechanical and electronic products for automation and instrumentation.

There's no obligation to learn more about how BOEHME can be of help to you. Send for descriptive literature, *now!*

H. O. Boehme, Inc.
Designers and Manufacturers
Communication Equipment
Precision Electro-Mechanical
Apparatus Since 1917
915 Broadway New York 10, N.Y.

Circle 482 on Page 19

OSTUCO WELDED TUBING

solves your fabrication puzzles

Product design dilemmas . . . or production problems? Solutions to these perplexing puzzles fall right into place *naturally—with Ostuco Welded Tubing.*

First, Ostuco Welded Tubing is one of the most versatile of all materials. It can be subjected to virtually every fabricating operation known.

Second, we can perform any one or more of these fabricating operations. That means you add us to your production line without investment in equipment, inventory or plant.

Third, when you deal with Ohio Seamless you're dealing with tubing *experts* . . . men who can recommend the *exact* Ostuco Welded Tubing to suit your product and processes. Just contact our nearest sales office, or the plant at *Shelby, Ohio—Birthplace of the Seamless Steel Tube Industry in America.*

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FIFTY YEARS
OSTUCO
OSTUCO TUBING
1908 1958

OHIO SEAMLESS TUBE DIVISION

of Copperweld Steel Company · SHELBY, OHIO

Seamless and Electric Resistance Welded Steel Tubing • Fabricating and Forging

SALES OFFICES: Birmingham, Charlotte, Chicago (Oak Park), Cleveland, Dayton, Denver, Detroit (Huntington Woods), Houston, Los Angeles (Lynwood), Moline, New York, North Kansas City, Philadelphia (Wynnewood), Pittsburgh, Richmond, Rochester, St. Louis, St. Paul, St. Petersburg, Salt Lake City, Seattle, Tulsa, Wichita. CANADA: Railway & Power Engr. Corp., Ltd. EXPORT: Copperweld Steel International Company, 225 Broadway, New York 7, New York.

Save Cost of Threading!

Also ELIMINATE

--Notching

--Drilling for cotter pins

These low-cost, vibration-proof, tempered spring steel PALNUT fasteners assemble fast—hold tight on *unthreaded* zinc die-cast studs; also on *unthreaded* rod and wire of steel, aluminum or brass.

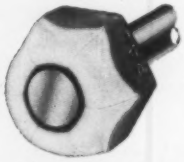
PALNUT SELF-THREADING LOCK NUTS

Form deep, clean threads on unthreaded studs or rod while tightening. Provide vibration-proof grip on studs, whether seated for load-carrying, or unseated as a "stop" nut. Adequate prevailing torque keeps nut in position. Hex form fits all standard tools for easy fast assembly. Washer base spans holes and slots. Also available with sealer washer. May be removed and re-used. Sizes for 1/8", 3/16" and 1/4" dia. rod or studs.

Type C (closed end)

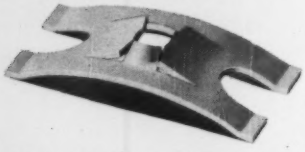
PUSHNUT® FASTENERS -- ACORN TYPE

Simply push or tap on unthreaded rod, wire or rivets to lock securely. Saves threading, notching or drilling for cotter pins. Locking grip at base resists removal. Smooth contour of Acorn Type C covers rod ends. Type CK has open end, assembles with rod end flush with PALNUT. Six sizes from .120" to .312" dia. rod or wire.



Type CK (open end)

PUSHNUT® FASTENERS -- FLAT TYPE H



Quickly push on unthreaded studs, rod or rivets to provide tight, rattleproof assemblies. Four gripping teeth, long spring arch, turned up edges assure full seating and resilient grip, even on hard chrome studs. Fast assembly with PALNUT applicators. Sizes for 1/16", 3/32" and 1/8" dia. studs.

PUSHNUT® FASTENERS -- TYPE W

Made of heavy gauge, tempered spring steel with powerful gripping action when pushed on unthreaded rod or axles. Will not cock, misalign or deform in assembly. One-piece construction. Removal forces from 100 to 1,000 lbs., according to size. Available for 3/16" 3/8" and 7/16" rod.

Write for free samples, stating type, size and intended application.

THE PALNUT COMPANY, 75 Glen Road, Mountainside, N. J.

In Canada: P. L. Robertson Co., Ltd., Milton, Ont.

PALNUT® LOCK NUTS FASTENERS PAL®

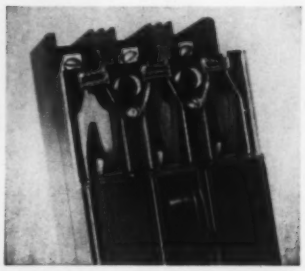
Quick, secure fastening at low cost

Coefficient of expansion is 10 x 10^{-7} cm/cm/degree C. Service temperature is 2000 F. Materials are particularly resistant to molten aluminum. **Corning Glass Works,** Corning, N. Y. D

Circle 624 on Page 19

Circuit Breaker

has visible contacts



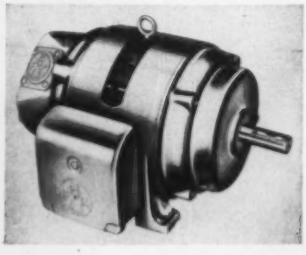
Saf-T-Vue circuit breaker incorporates a removable, transparent cover through which contacts can be viewed. Any darkening of window indicates a short circuit, and windows can be replaced easily and inexpensively. Breakers are available in a variety of frame sizes. **Standard Control Div., Westinghouse Electric Corp.,** Beaver, Pa. F

Circle 625 on Page 19

Capacitor Motors

provide high starting torque

Type WCZK heavy-duty, single-phase, integral-horsepower motors provide high starting torque and operating efficiency. For starting, motors use dry electrolytic capacitors designed for maximum starting torque with minimum current usage. When motor gains speed, a centrifugal switch cuts out the capacitors for straight induction run. Motors are especially suited for service with pumps, fans, drill presses, lathes, sanders, circular saws, laundry washers, brine agitators, pulp



grinders, and similar equipment. They are available from ¾ to 1½ hp at 1200 rpm, 1 to 3 hp at 1800 rpm, and 1½ to 5 hp at 3600 rpm. **Fairbanks, Morse & Co.**, 600 S. Michigan Ave., Chicago 5, Ill. I

Circle 626 on Page 19

Ultrathin Foil

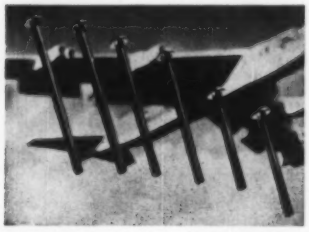
in zirconium and titanium

Two metals now being processed from ingot to foil are zirconium and titanium. Zirconium ingots are forged, hot and cold rolled, vacuum annealed, and precision cold rolled to a thickness of 0.0008 in. Zirconium foil is used in photographic flashbulbs. Pure titanium foil is rolled to a minimum thickness of 0.0003 in., and titanium alloys to 0.002 in. Foil has good corrosion resistance and high strength-to-weight ratio. Applications include use in the manufacture of honeycomb structure for jet aircraft, use in jet aircraft engine shrouds, electronic tubes, and diaphragms. **Precision Metals Div., Hamilton Watch Co.**, Lancaster, Pa. E

Circle 627 on Page 19

Inconel Rivets

for use in temperatures to 1800 F



Tubular and solid Inconel rivets retain strength and resist oxidation at temperatures to 1800 F. Head is free of cracks, and metal is of uniform quality. Rivets shown are 1.153, 1.333, 1.533, 1.833, and 2.083 in. long by 0.123 in. diam. **John Hassall Inc.**, Westbury, L. I., N. Y. D

Circle 628 on Page 19

Temperature Controller

for electrically heated devices

Compact controller adjusts and regulates power input to electrically heated devices such as ovens and

4 Reasons Why

OHIO Stock Gears are a Better Buy!

1 Better Value

OHIO gears are a better value because you get top quality gears at lower prices. Ask for a quotation and see for yourself.

2 Top Quality

OHIO gears have gained universal acceptance among major users, through a combination of experienced engineering, fine materials and quality workmanship.

3 Availability

52 OHIO distributors, located in major cities across the nation, can make fast delivery on all popular styles and sizes . . . from local stock.

4 Wide Selection

All sizes of OHIO gears are available in both 14½ and 20 degree pressure angle, and includes: spur, 3 to 64 pitch; worm, 3 to 32 pitch; bevel, 3 to 16 pitch; mitre, 4 to 32 pitch; and helical, 6 to 24 pitch.

Why not make your own comparison by getting a competitive quotation on your stock gear needs. See your local OHIO distributor or write direct.

Get This Handy Catalog — the only gear catalog planned and indexed to put complete information at your finger tips.

Ohio **OHIO GEAR Company**

1338 East 179th St. • Cleveland 10, Ohio

Circle 485 on Page 19

WHAT CAN YOU DO WITH THIS FLEXIBLE, DURABLE METAL-MESH FABRIC?

Metal-mesh fabric—flexible, durable and with open mesh—has been accepted for years as a basic material for the fabrication of woven wire conveyor belts. Recently, though, resourceful design and production men have been finding new uses for this versatile woven wire construction. For example, slings for materials handling, protective curtains for forging operations, containing curtains for heat treating operations, tread reinforcements for modern high speed tanks, and even such domestic articles as doormats, fireplace screens and flexible room dividers.

Here are the important physical characteristics of metal-mesh fabric. How can you use them in your designing or production operations?

FLEXIBILITY—spiraled wire construction gives complete one-direction flexibility. You can coil it, draw it up on itself as a curtain or take it around corners.

OPEN MESH—Mesh size can be varied from 1/64" to 2½" or larger to provide for the passage of air, liquids, light or gases, but retain solid matter or particles.

DURABILITY—this fabric is of all-metal construction and can be produced in any metal or alloy, thus can be made resistant to heat, cold, corrosion, erosion or damage from impact or shock.

VARIETY—metal-mesh fabric can be woven to any length or width and in any of nine basic patterns. Further, any number of special side, surface or end attachments can be fitted to it.

WANT A SAMPLE?

Simply tell us what you have in mind as a possible use for metal-mesh fabric and we'll make up a sample section for your inspection and testing. Our own Field Engineer in your territory will deliver your sample to you personally and discuss your application with you.

Write direct or look under "Wire Cloth" in your classified telephone directory to talk to the Cambridge man nearest you.

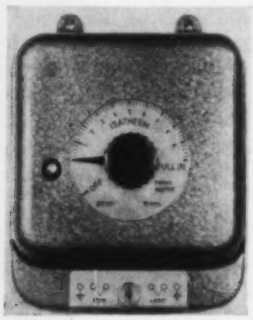
The Cambridge Wire Cloth Co.

WIRE CLOTH | METAL-MESH CONVEYOR BELTS | WIRE CLOTH FABRICATIONS

Department N, Cambridge 6, Maryland

OFFICES IN PRINCIPAL INDUSTRIAL CITIES

Circle 486 on Page 19



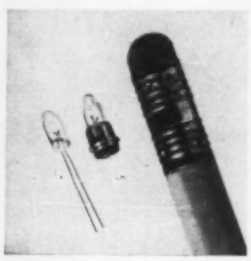
furnaces by interrupting the current supply at a variable rate. Unit automatically compensates for line voltage and ambient temperature fluctuations. Bimetal switch, operating through a mercury switch, interrupts power at a rapid rate to prevent overshoot. Adjustment permits reproducibility of setting to about 1 F in a given system. Unit controls from 115-v ac circuit with 10 amp maximum current. **E. Vernon Hill & Co.**, P.O. Box 189, Lake Geneva, Wis. K

Circle 629 on Page 19

Subminiature Lamp

is 1/8 x 1/4 in. long

New subminiature lamp has life expectancy of 60,000 hr, and measures 1/8 x 1/4 in. long. It is rated at 5 v, and withstands voltage



surges to 30 v. Unit resists vibration damage. **Chicago Miniature Lamp Works**, 1500 N. Ogden Ave., Chicago 10, Ill. J

Circle 630 on Page 19

Self-Bonding Nameplates

are made of Mylar

New Mylar self-bonding nameplates are made to specifications as dials, rating plates, instruction plates, or decorative trim. Named Poly-Plates, they are subsurface-printed, metalized, and sealed to assure permanent legibility of legend.

Plates are reproduced to exact color match, and insignia, artwork, and half-tones can be incorporated in the design. Subsurface legend is protected from salt spray, solvents, and detergents by clear film in a one-piece construction. The nonconductive plates can be applied to flat or curved painted or unpainted metal, wood, plastic, and glass surfaces without application tools. Plates are furnished in sizes from ¼ x ½ in. to 15 x 10 in. in 3 and 5-mil thicknesses. **W. H. Brady Co.**, 727 W. Glendale Ave., Milwaukee 9, Wis. K

Circle 631 on Page 19

DC Brake

provides torque ratings of 10 to 105 lb-ft

Shunt-wound dc brake can be floor mounted or motor mounted on motors utilizing a stub shaft, a

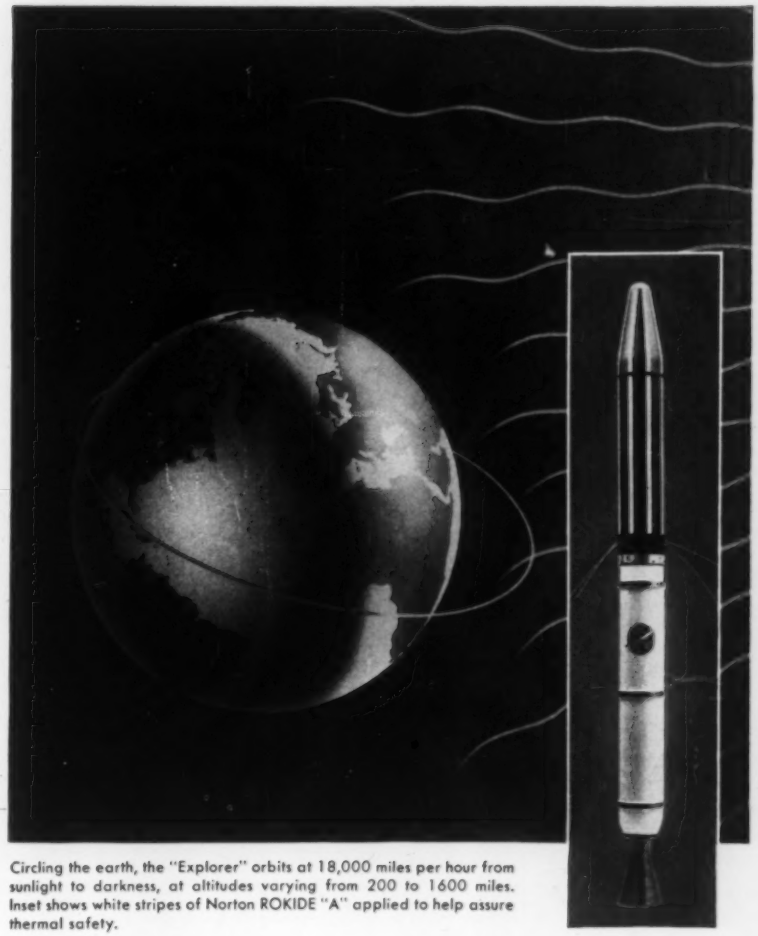
standard double-shaft extension, or can be modified for through-shaft applications. Unit provides torque ratings from 10 to 105 lb-ft, with both standard and dust-tight, waterproof enclosures available. Features include single-solenoid construction, single-point adjustment for lining wear, visual indication of lining wear, and manual release, automatic reset. **Stearns Electric Corp.**, 120 N. Broadway, Milwaukee 2, Wis. K

Circle 632 on Page 19

Flowmeter

measures flow in 1½ to 8-in. pipes

Mighty-I indicating flowmeter measures flow in either direction in any pipe size from 1½ to 8 in. without use of additional components or accessories. The corrosion-resistant unit requires no flanges or orifice plates and is installed in any line easily. Unit is suitable for services



Circling the earth, the "Explorer" orbits at 18,000 miles per hour from sunlight to darkness, at altitudes varying from 200 to 1600 miles. Inset shows white stripes of Norton ROKIDE "A" applied to help assure thermal safety.

Hotter than fire . . . colder than ice

ROKIDE coating protects the "Explorer" through temperatures from 600°F to 150° below zero.*

Completing its orbit every 118 minutes, the "Explorer" speeds between blazing daylight and black night every hour, through temperatures ranging from 600°F to 150°F below zero.

The resultant thermal risks, especially to instruments, are enormous. By striping the satellite's nose cone and instrument section with ROKIDE "A" aluminum oxide spray coating, Jet Propulsion Laboratory scientists were able to maintain a safe internal temperature range.

ROKIDE "A", "ZS" and "Z" coatings are hard, crystalline refractory oxides. These Norton developments have high resistance to excessive heat, abrasion and corrosion that has proved valuable not only in reaction motors and AEC projects, but to general industry..... .....in applications involving electrical insulation, electronics, bearing surfaces, erosion resistance, chemical barriers, material upgrading, surface catalyst activity and altering emissivity and characteristics of surfaces.

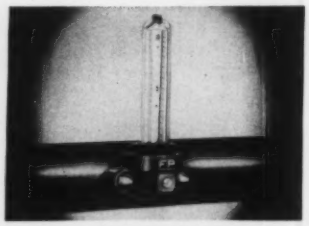
Facilities for applying ROKIDE coatings are maintained at Norton Company, Worcester, Mass., and at its plant at 2555 Lafayette Street, Santa Clara, Cal. For the latest ROKIDE Bulletin write to NORTON COMPANY, 765 New Bond Street, Worcester 6, Massachusetts.

NORTON
NEW PRODUCTS
Making better products... to make your products better

*Trade-Mark Reg. U. S. Pat. Off. and Foreign Countries

NORTON PRODUCTS Abrasives • Grinding Wheels • Grinding Machines • Refractories • Electrochemicals
BEHR-MANNING DIVISION Coated Abrasives • Sharpening Stones • Pressure-Sensitive Tapes

Circle 487 on Page 19



with flow ranges up to 10:1. Readings are made directly by means of a ball float and linear scale calibrated in gallons per minute. Scales covering flow rates from 3-30 to 200-2000 gpm are available. **Fischer & Porter Co.**, 677 Jacksonville Rd., Hatboro, Pa. E

Circle 633 on Page 19

Subminiature Switch

circular unit has 10-amp capacity

New Q snap-action subminiature switch has applications in vending devices, electronic equipment, appliances, business machines, automotive products, and communications equipment. Carrying a 10-amp, 115-v capacity, it utilizes a circular design which makes it adaptable to space-conserving applications. Device is available with

panel mount and pushbutton actuator. Quick-disconnect terminals are also available. **Acro Div., Robertshaw-Fulton Controls Co.**, 2040 E. Main St., Columbus 16, Ohio. G

Circle 634 on Page 19

Aluminum Bronze Alloy

resists stress corrosion cracking

Grade 8 aluminum bronze alloy eliminates the need to stress relieve finished fabrications to guard against stress corrosion cracking. Field changes, alterations, or repairs can be made freely without heat treatment. A small amount

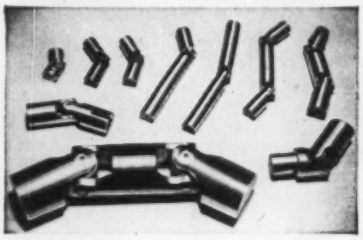
GET FACTS YOU SHOULD KNOW ABOUT TUBING
NEW TUBING DATA BOOK FREE!
Complete technical data for designers, plant engineers, purchasing agents. Specifications, applications, and how to order interlocked and corrugated flexible tubing, vibration absorbers, expansion joints.
It's a book you need to improve your knowledge of tubing. Yours free. Send request on company letterhead to Dept. 58, Pennsylvania Flexible Metallic Tubing Co., 7239 Powers Lane, Philadelphia, Pa.
GET YOUR COPY
PENFLEX
TIGHT AS A PIPE BUT...
FLEXIBLE

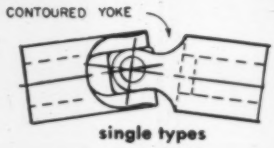
Circle 488 on Page 19

Lovejoy

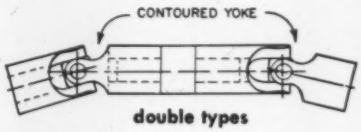
UNIVERSAL JOINTS

INDUSTRY'S MOST COMPLETE LINE FOR EVERY SLOW SPEED APPLICATION





single types



double types

Check these features against your requirements:

Special Contoured Yoke—capable of operating at a maximum angular misalignment of 45° on hand-operated applications.

Static Torque—from 306 to 129,693 in.-lbs. at 12°, depending on size of joint.

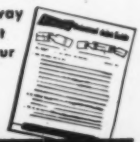
Horsepower Ratings—.54 to 207 at 100 rpm.

Tolerances—pins ground to .0005" ...forks concentric to within .001" ...precision accurate center blocks.

Standard Specifications—hub diameters ½ to 4"...bores ¼ to 2" ...lengths (single) 2 to 10⅝", (double) 4 to 21¼". All specifications can be altered or special joints designed to individual requirements.

Get this handy guide

It's the quick and easy way to get the Universal Joint that is just right for your application. Request Bulletin 820.



LOVEJOY FLEXIBLE COUPLING CO.

4818 W. Lake St. **Chicago 44, Ill.**

Circle 489 on Page 19

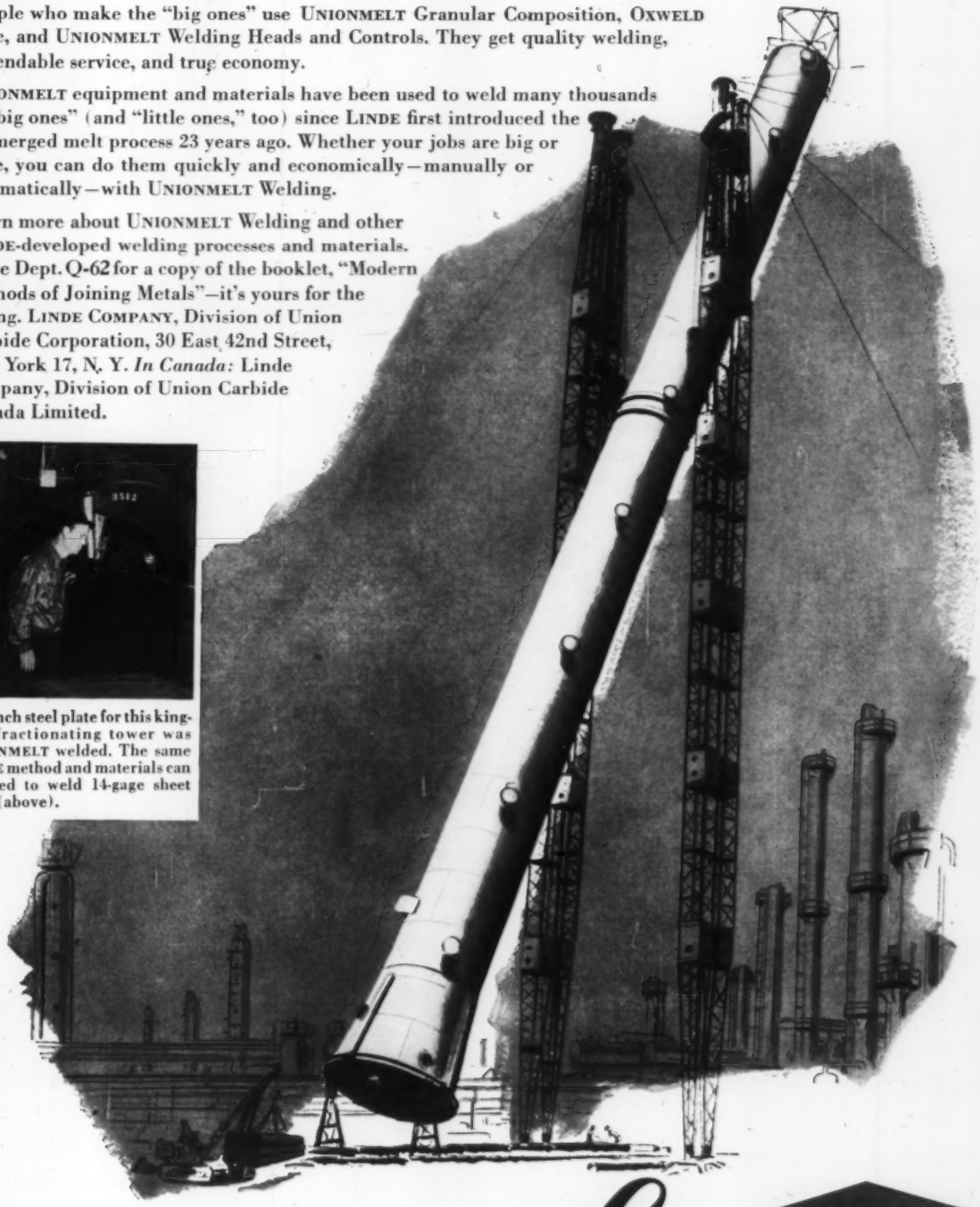
UNIONMELT Welding
makes short work of tall towers

People who make the "big ones" use UNIONMELT Granular Composition, OXWELD Wire, and UNIONMELT Welding Heads and Controls. They get quality welding, dependable service, and true economy.

UNIONMELT equipment and materials have been used to weld many thousands of "big ones" (and "little ones," too) since LINDE first introduced the submerged melt process 23 years ago. Whether your jobs are big or little, you can do them quickly and economically—manually or automatically—with UNIONMELT Welding.

Learn more about UNIONMELT Welding and other LINDE-developed welding processes and materials. Write Dept. Q-62 for a copy of the booklet, "Modern Methods of Joining Metals"—it's yours for the asking. LINDE COMPANY, Division of Union Carbide Corporation, 30 East 42nd Street, New York 17, N. Y. *In Canada:* Linde Company, Division of Union Carbide Canada Limited.

One-inch steel plate for this king-size fractionating tower was UNIONMELT welded. The same LINDE method and materials can be used to weld 14-gage sheet steel (above).



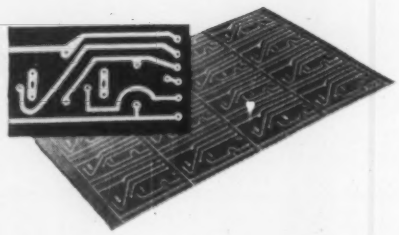
Linde

UNION CARBIDE

The terms "Linde," "Unionmelt," "Oxweld," and "Union Carbide" are registered trade-marks of Union Carbide Corporation.

Circle 490 on Page 19

cold-punch 'em fast without the cost of fixed dies!



it's easy with the **strippit**

FABRICATOR-DUPLICATOR

As fast as the operator places the Duplicator stylus in each template pilot hole, the printed circuit board or other work is automatically positioned under the Fabricator punch and the punch tripped. Anyone can learn to operate the Fabricator-Duplicator in a few minutes. Consistently clean holes are produced in laminates from paper base phenolic to glass base epoxy, copper clad one or both sides from .032″ to .125″ thick — without cracks. Tool changes are made in a few seconds, using Strippit interchangeable standard round, obround, square or special-shape tools.

BUT WHY NOT SEE the Fabricator-Duplicator — and the time-saving new Dupl-O-Scope template-punching attachment — perform on your work at your plant? Write today for complete literature and a demonstration by a Strippit mobile unit! Warehouse stocks in Chicago and Los Angeles for fast deliveries.

WALES STRIPPIT COMPANY

216 Buell Road

Akron, N. Y.

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In Canada:

Strippit Tool & Machine Limited, Brampton, Ontario

A UNIT OF HOUDAILLE INDUSTRIES, INC.

Circle 491 on Page 19

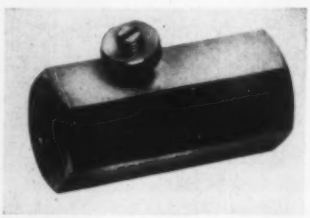
(0.33 per cent) of tin or silver, added to the alloy, produced the modification to eliminate stress corrosion cracking. Material is permitted for use in the construction of ASME-approved pressure vessels, and can be used at temperatures to 500 F with allowable working stress of 10,000 psi. Applications include use in steam exposure and distillation equipment, and in high-pressure piping. **Ampco Metal Inc.**, 1745 S. 38th St., Milwaukee, Wis. K

Circle 635 on Page 19

Valves

for hydraulic and gas applications

New line of check and flow-control valves for hydraulic and gas applications utilizes straight-through ball-valve design to provide increased flow, greater dependability, and marked reduction in friction. Precision metal-to-metal seats and free-ball mounting assure lower



maintenance costs and more consistent flows. Valves are female-threaded to dryseal specifications in standard IPS from $\frac{1}{8}$ to $\frac{3}{4}$ in. and are available from stock in brass. They can be used in all pressure ranges to 2000 psi, and are particularly adaptable to extremely high or low temperature ranges. **Tru-Flo Valve Div., Mystic Machine Co. Inc.**, Everett 49, Mass. B

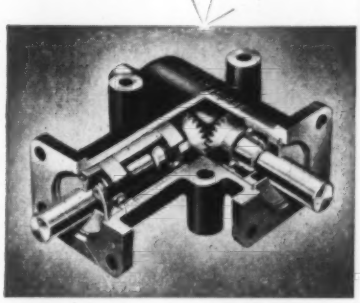
Circle 636 on Page 19

Motors

from 1 to 500 hp

Line of totally enclosed and explosionproof motors from 1 to 500 hp is designed specifically for industrial applications. Motors are available in new Nema frames through 365U, old Nema frames through 505, and standard industrial frames above 505 through 500 hp. Motors have recessed neoprene slingers on output shaft, new lubrication system,

NEW 2¼ HP ANGLgear® HELPS SIMPLIFY YOUR 90° DRIVE PROBLEMS



Hardened bevel gears and antifriction bearings insure smooth, trouble-free operation. Completely enclosed, permanently lubricated ANGLgear requires little or no maintenance.

Addition of the new 2¼ hp size to the ANGLgear line makes it easier than ever to solve your 90° power takeoff problems with this standardized right-angle drive. You can now specify ANGLgear in any one of 16 different stock models, offering power ratings from ⅓ to 5 hp, with choice of 1:1 or 2:1 gearing and 2 or 3-way shafting.

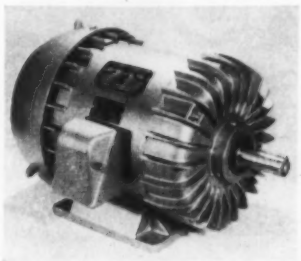
Compact, high capacity ANGLgear offers you several distinct advantages over V-belts or chains and sprockets. Featuring 5-way mounting, it is easier to design into your power transmission systems. Incorporating positive bevel gear drive, it eliminates slippage and backlash problems. Completely enclosed, it presents no safety hazards. Permanently lubricated, it requires virtually no maintenance. And not the least important, ANGLgear invariably costs less than other types of 90° drives.

See our literature in Sweet's Product Design File or contact your local distributor.

AIRBORNE®

AIRBORNE ACCESSORIES CORPORATION
HILLSIDE 5, NEW JERSEY

Circle 492 on Page 19



stainless-steel connection and nameplates, and shock-resistant fan covers. All models have indexed leads and balanced insulation system impervious to moisture and corrosive atmospheres. **Electric Motor Div., A. O. Smith Corp.**, Tipp City, Ohio. G

Circle 637 on Page 19

Glass Fiber Laminate

has high strength retention after 150-C temperature

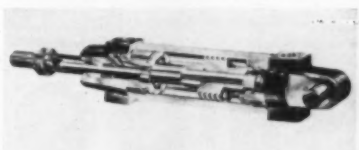
New epoxy-bonded glass fiber laminate, identified as Phenolite Grade G-11-861, retains 70 to 80 per cent of original flexural strength when tested at 150 C after conditioning for 1 hr at that temperature. Material offers excellent electrical properties and high mechanical strength of epoxy-bonded materials, plus high heat resistance. It is also available in a copper-clad form for printed-circuit applications, particularly for military electronic circuits in rockets, missiles, and computers. Material meets military requirements for Type GEE under MIL-P-18177-A. It is available in sheet sizes of 39 x 47 and 39 x 39 in., in thicknesses from 1/32 to ½ in. **National Vulcanized Fibre Co.**, Box 311, Wilmington, Del. C

Circle 638 on Page 19

Hydraulic Cylinder

has operating pressures of 1000, 2000, and 3000 psi

Spacemaker high-pressure hydraulic cylinder is available in cushioned or noncushioned type, with forged-steel heads, self-aligning, adjustable



Cup Seals by LINEAR

in Viton A, Vyram, Polyurethane, and other unusual elastomeric materials having excellent resistance to many petroleum oils, synthetic lubricants, fuels, phosphate and silicate ester fluids—in a temperature range of —40° to + 500°F.

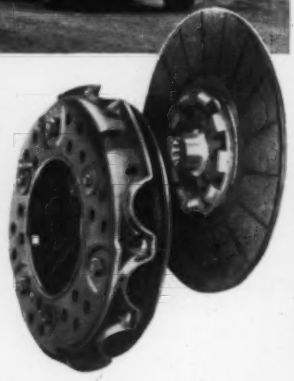
LINEAR—specialists in close-tolerance molding in all of today's modern polymers . . . in both fabric reinforced and homogeneous materials.

These are low friction seals. For further help, call the LINEAR engineer.

PERFECTION IN RUBBER
LINEAR
LINEAR, Inc., STATE ROAD & LEVICK ST., PHILA. 35, PA

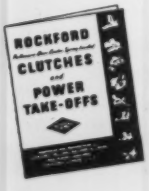
Circle 493 on Page 19

ROCKFORD



CLUTCHES
Are Adapted for Use with High-Speed Engines

Because modern construction methods require faster and faster delivery hauls with more and more cycles per hour, high speed engines are a must. The centrifugal force they develop presented a clutch problem—until ROCKFORD CLUTCHES were designed to minimize the effect of their multiplied degree of centrifugal force. If you want your heavy-duty machines to stay more hours ON THE JOB with less time IN THE SHOP—for adjustments and repairs—it will pay you to investigate the more torque grip, longer work life, and better heat disposal provided by ROCKFORD CLUTCHES.



SEND FOR THIS HANDY BULLETIN
Shows typical installations of ROCKFORD CLUTCHES and POWER TAKE-OFFS. Contains diagrams of unique applications. Furnishes capacity tables, dimensions and complete specifications.

Small Spring Loaded

Automotive Spring Loaded

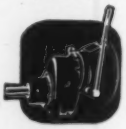
Heavy Duty Spring Loaded

Oil or Dry Multiple Disc

Heavy Duty Over Center

Light Over Center

Power Take-Offs


Speed Reducers

ROCKFORD B-W BORG-WARNER

ROCKFORD Clutch Division BORG-WARNER
311 Catherine St., Rockford, Ill., U.S.A.
Export Sales Borg-Warner International — 36 So. Wabash, Chicago 3, Ill.

CLUTCHES

cushion, high-pressure piston-ring construction with three types of oversize ports, and long rod-guide bearing. Cylinder has operating pressures of 1000, 2000, and 3000 psi. **Tomkins-Johnson Co.**, Jackson, Mich. H

Circle 639 on Page 19

Frequency Meter

with scale readable to 0.25 per cent accuracy

New 400-cycle expanded-scale frequency meter for panel mounting is a self-contained, needle-indicator unit with standard 380 to 420-cycle scale readable to accuracies of 0.25 per cent over its entire range. Applications include missile and aircraft support equipment, laboratories, and fixed power supplies requiring accurate frequency monitoring. Frequency is detected by a transformer and full-wave rectifier. Variations in line frequency result in proportional variations of dc voltage output. Voltage is applied to the bridge which is nulled at the value representing 380 cycles. At frequencies between 380 and 420 cycles, bridge provides an output linearly proportional to input frequency. Meters are available in round, square, and rectangular types for panel mounting. **Helipot Corp., Div., Beckman Instruments Inc.**, Newport Beach, Calif. L

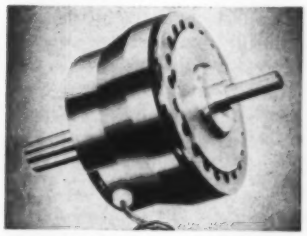
Circle 640 on Page 19

Hysteresis Clutch

uses a stationary coil for excitation

Model HCS-500 hysteresis clutch has rating of 140 oz-in. torque. Use of a stationary coil for excitation eliminates rotating-coil construction and slip rings. Torque can be controlled by the current setting from zero to maximum rating, relatively independent of slip-speed

Circle 494 on Page 19



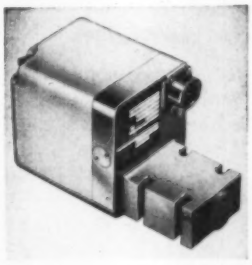
characteristics. Clutching action is magnetic, no friction or mechanical contacting members being used. **Magtrol Inc.**, 240 Seneca St., Buffalo 5, N. Y. F

Circle 641 on Page 19

Servo Valves

provide high-speed response with low-power output

Series 5214 electrohydraulic servo valves are high-performance, flow-control units used for guidance or control transfer where high-speed response with low power output is required. Excellent phase and amplitude responses are easily obtained in low flow applications. Direct drive and dry torque motor design of the single-stage valves provide reliable servo valve with flow outputs to 1 gpm. Models are available for operation at supply pressures to 3000 psi, flows to 1 gpm, fluid temperatures from −65 to 180 F, and



ambient temperatures from −65 to 250 F. They have a natural frequency of 350 cps, and 90-deg phase lag occurs at 300 cps. Internal leakage is less than 15 cu in. per min. **Lear-Romec Div., Lear Inc.**, Abbe Rd., Elyria, Ohio. G

Circle 642 on Page 19

Temperature Control

is sensitive, remote-bulb unit

Type E98A explosionproof, dual-switch temperature control is a remote-bulb unit designed for use in

Here's the **NEW** variable-speed, explosion-proof Model 16AM

GAST rotary vane AIR MOTOR

Newest and largest Air Motor in the Gast line, this Model 16AM may solve an original equipment (or plant use) problem for you! It's compact — only 14⅜" x 8" x 7⅝" high. It's light in weight — only 65 pounds. It delivers up to 7 h.p. with good torque characteristics.

Listing at $200, it offers unique advantages for driving equipment located near a compressed air source:

1. Speed infinitely variable from 300 to 2,000 r.p.m. with any simple air valve control. Air motors always run cool.
2. Explosion-proof design, safe in explosive atmospheres.
3. Can't burn out from overloads — stalling doesn't harm it.
4. Heavy-duty construction with ball bearings, dual seals.
5. Six vanes in rotor automatically take up their own wear for constant high efficiency and long life.

Designed to operate on air pressures from 30 to 90 p.s.i., Model 16AM is suitable for driving direct, through gear box or pulley. Foot (base) is standard. End plate also has four tapped holes for flange mounting to gear box or other driven unit.

Perhaps you can use air power on a hoist, fan, pump, mixer or other product. Write today for new Bulletin 16AM.

GAST MANUFACTURING CORP., P.O. Box 117-P, Benton Harbor, Michigan

SEE CATALOG IN SWEET'S PRODUCT DESIGN FILE & A.S.M.E. CATALOG

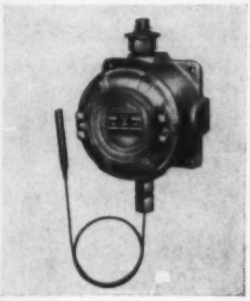
GAST ROTARY

- AIR MOTORS TO 7 H.P.
- COMPRESSORS TO 30 P.S.I.
- VACUUM PUMPS TO 28 IN.

"Air may be your answer!"

Circle 495 on Page 19

hazardous locations where explosive vapors and gases are present. Two separate switches permit switching action above or below set point, control of two independent circuits, and flexibility of switching arrangement. Temperature settings



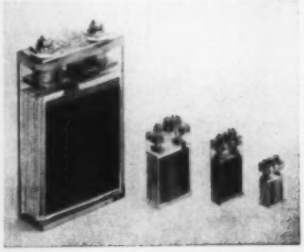
are made by rotating a single-turn knob and pointer over a calibrated dial. Individual adjustment of switches is accomplished by independent, recessed hex-head screws which provide for approximately 15-F span between switch settings, constantly maintained throughout control range. All switches are single pole and suitable for 180-F ambient temperature. **United Electric Controls Co.**, 79 School St., Watertown, Mass. B

Circle 643 on Page 19

Storage Batteries

have low internal resistance

Improved sintered-plate, nickel-cadmium storage batteries have nominal discharge of 1.2 v per cell, permitting batteries to be made up in multiples of 1.2 v. Low internal resistance (0.001 ohm for 10 amp-hr cell) permits high discharge currents. Absence of corrosive fumes is advantageous in enclosed spaces. Cells illustrated have capacities of 64, 5, 2, and 1 amp-hr, with capacities ranging from ½ to over 150 amp-hr. Uses include portable electronic equipment, missile auxil-



WHAT'S YOUR CLAMPING PROBLEM?
WITTEK
HAS THE ANSWER
Here is a selection from among the many different types and sizes of hose clamps designed and manufactured by WITTEK. Whatever the hose connecting problem, it's a safe bet that WITTEK (leader for over a quarter century) has the exact type and size clamp to do the job right! Let WITTEK help solve your clamping problems. Write today.
5187
WITTEK MANUFACTURING COMPANY
4349 West 24th Place • Chicago 23, Illinois

Circle 496 on Page 19

iary power, aircraft engine starting, and data processing. **Nicad Div., Gould-National Batteries Inc.**, Easthampton, Mass. B

Circle 644 on Page 19

Temperature Relief Valves

open at 210 F and close at 180 F

Type TR self-closing temperature relief valves provide temperature protection for hot-water tanks and heaters already protected by a pressure-only relief valve. Valves are bronze with brass internal parts, have silicone seat disc and positive-acting thermostat which opens valves

at 210 F and closes them at 180 F. Maximum pressure is 150 psi. Valves are available in eleven models and meet Type 2 requirements of MIL-V-13612 as amended. **A. W. Cash Valve Mfg. Corp.**, P. O. Box 191, Decatur, Ill. I

Circle 645 on Page 19

Plastic Packing

for high-speed seals

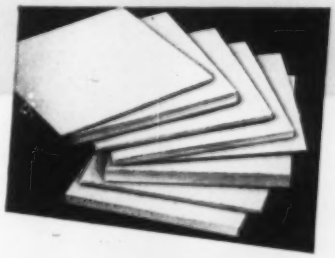
Fluoropack is a nongelling, putty-like packing material which is moldable under pressure to the contour of any stuffing box. Designed for use on high-speed shafts, it retains corrosive liquids without leakage, heat build-up, or shaft scoring. Material is composed of finely divided Teflon, compounded with a blend of special fractions of polychlorotrifluoroethylene oil. Packing will not bleed except under elevated temperatures and pressures. Normal service temperature range is − 40 to 350 F, but packing can be used to 450 F where pressures are low. Self-lubricating and chemically inert to oxidizing and reducing agents, acids, and alkalis, packing has no

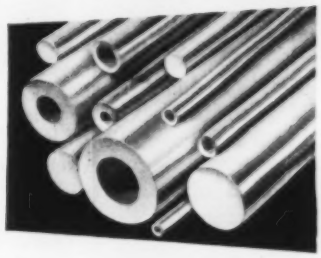
TEFLON

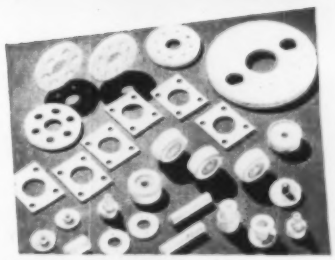
SHEET....ROD....

TUBING....MOLDED OR MACHINED PARTS?

YOU CAN GET JUST WHAT YOU WANT







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Circle 497 on Page 19

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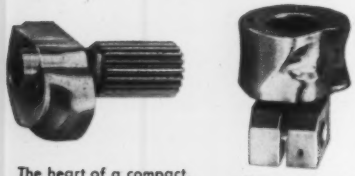

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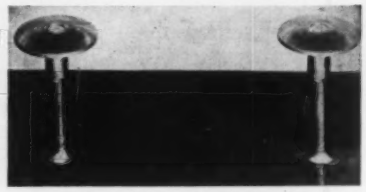
Circle 498 on Page 19

effect on elastomers such as polyvinyl alcohol, polysulfides, Buna-N rubber, Hycar, and Neoprene GN. Some swelling may occur with natural rubber, Buna S, silicone rubbers, and polyethylene. **Halocarbon Products Corp.**, 82 Burlews Court, Hackensack, N. J. D

Circle 646 on Page 19

Threadless Stud Cap

of aluminum alloy

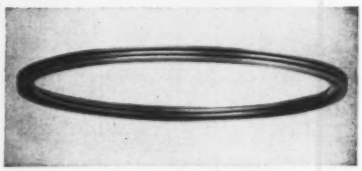


New threadless stud cap of 2117 aluminum alloy features a positive interference lock for high retention strength. Cap is designed for use with threadless steel studs in either 1/8 or 3/16 in. nominal diameters. Variety of shank lengths permit application over a wide range of material thickness. Cap is installed by tapping it onto the annularly grooved stud with a hammer. Optimum interference fit insures positive cap retention in assembly. Head diameter of 1 in. provides a broad bearing area for positive installation on a wide variety of materials. **Huck Mfg. Co.**, 2480 Bellevue Ave., Detroit 7, Mich. H

Circle 647 on Page 19

Spring-Seal

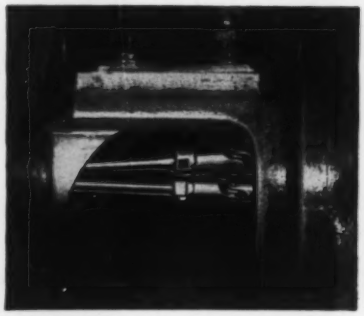
for temperatures to 1000 F



New high-temperature seal is used as a spring and as a pressure seal. It has a controlled spring load of 20 lb ±2 lb at 0.040 in. deflection. Operating at temperatures to 1000 F, unit shown is a 5 in. OD size. It is also available in 1/2 to 33-in. OD sizes for existing temperature and pressure requirements. **Skinner Seal Co.**, 3001 Sutter St., Santa Ana, Calif. L

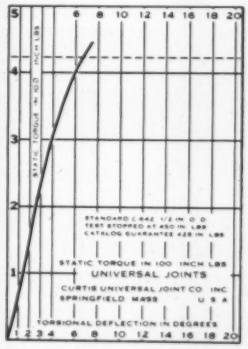
Circle 648 on Page 19

Solving a breakage problem AT CLOSE QUARTERS



The manufacturer of this button-drilling machine had a tough problem: the universal joints on these parallel shafts carried such a torque load there were frequent complaints of breakage . . . yet the close centers prohibited use of a larger joint.

THE SOLUTION was a Curtis Universal Joint of the same size.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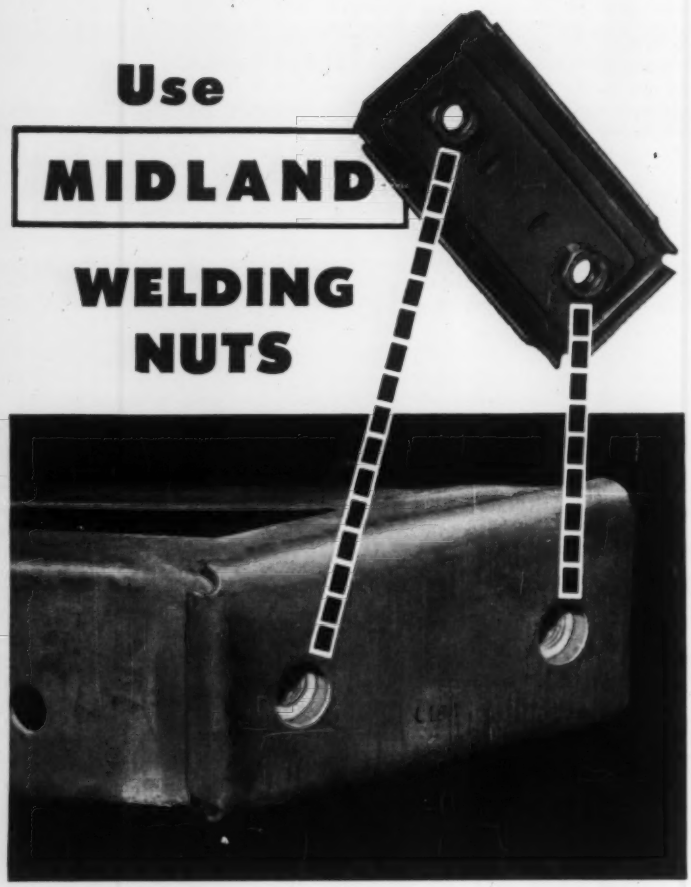

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ENGINEERING DEPARTMENT

EQUIPMENT

Tacking Device

for drafting and architectural uses

Tack-N-Taker is a multipurpose instrument used to fix papers to drawing boards, and for other drafting and architectural uses. It automatically places tacks and reclaims them for subsequent use. Made in Switzerland, the 4-in. tubular tool is designed for needs commonly filled by tacks, push pins,

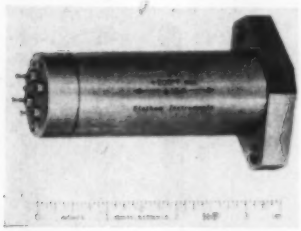
staples, tape, and similar items. Three-pronged reusable steel tacks easily penetrate materials such as wood, cork, fiberboard, and linoleum, remaining secure until removed by the tool. **Colorfix Import Co.**, 1409 Willow St., Minneapolis, Minn. J

Circle 649 on Page 19

Accelerometer

is gas damped for wide ambient-temperature range

Model A501 unbonded strain-gage accelerometer utilizes gas damping to permit operation of the device over a wide temperature range without addition of a heater jacket. Performance of the new unit excels conventional accelerometers in frequency response by a factor of two. At temperature extremes, such as − 65 to 200 F, useful frequency band of the unit is approximately the same as that of a conventional accelerometer at room temperature. Employing an unbonded strain gage as the transducing element, accelerometer is available in ranges from ±5 ± 50 g. Minimum size and



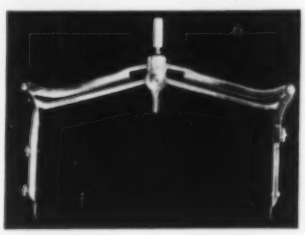
response characteristics make instrument suitable for use in missile and aircraft flight instrumentation. **Statham Instruments Inc.**, 12401 W. Olympic Blvd., Los Angeles 64, Calif. L

Circle 650 on Page 19

Drafting Instrument

compass contains telescopic extension

New Parallel compass, with automatic parallel opening of legs, holds pencil, pen, or needle point perpendicular to paper. Unit permits micrometric adjustment down to 0.001 in., and has gear-head construction. Telescopic extension, always parallel



to paper, gives radius of 13 in. when fully extended and permits drawing of circles to 26 in. **Unitech Corp.**, 50 Colfax Ave., Clifton, N. J. D

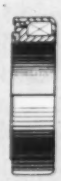
Circle 651 on Page 19

Direct-Writing System

six-channel systems is housed in single cabinet

Single vertical, mobile cabinet contains Model 156-5466 direct-writing oscillographic recording system, consisting of six driver amplifier power supply units and six-channel recorder assembly. System is completed by adding any of 12 interchangeable plug-in preamplifiers. Overall dimensions of the cabinet are 78 in. high x 22 in. wide x 25 in. deep. System provides 1 per cent overall linearity, nine chart speeds from 0.25 to 100 mm per sec, and clear, inkless recordings in

WHICH SEAL WILL SOLVE YOUR PROBLEM?

Seals drawn to same scale.				
Type of Seal	**Standard**	**Modified**	**Bellows**	**Shaft Surface**
Pressure (PSI)	1000	500	250	75
Speed (FPM)	15,000	15,000	15,000	15,000
Temperature (°F)	350° to 450°	—360° to 350°	—360° to 700°	500° to 700°
Uses	Fluids including aviation fuel, synthetic lubricants, etc.	Rocket motors, HNO_3, H_2O_2, NPN, LOX, Ethylene Oxide	Applications calling for all-metal, high temperature sealing	Sealing gaseous mediums in a minimum amount of axial space
Send for	Bulletin #7	Specially engineered	Bulletin #18	Bulletin #19

CAUTION: Maximum conditions indicated for each type do not necessarily imply that all are available in a single seal. Sealol engineers will gladly recommend the seal best suited to the operating conditions of your particular application. Write today . . . no obligation, of course!

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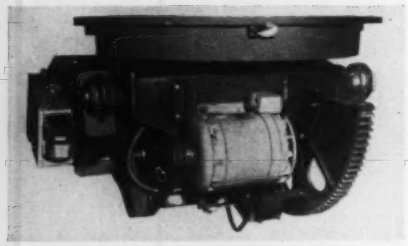
Circle 502 on Page 19

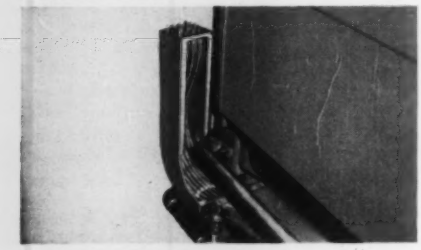
FLEXIBLE SHAFTS

...solve 3 design problems!
...save money on all 3!



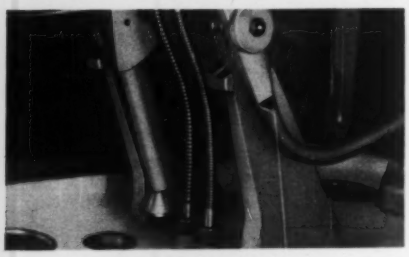
ROTARY WELDING POSITIONER

By using Robertshaw Flexible Shafting, the speed of the rotating welding table can be adjusted remotely allowing for the adjustment knob to be in a position most advantageous to the operator.



PRINTING PRESS

Robertshaw Flexible Shafting is used for ink fountain control on this modern printing press. 16 flexible connections to the keys controlling the fountain, provide a simple, economical way of achieving remote control.



POPCORN MACHINE

This popcorn machine tilts to various positions, demanding flexibility in the connections. Robertshaw Flexible Shafts transmit movement from the driving motor to the agitator... efficiently and at low cost.

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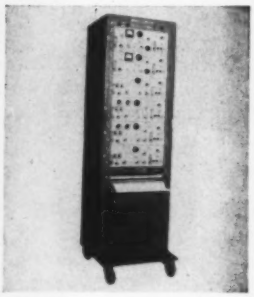


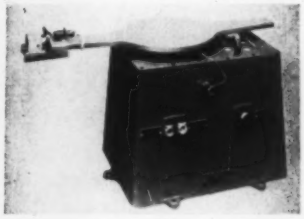
true rectangular co-ordinates by heated stylus on plastic-coated permanent paper charts. **Industrial Div., Sanborn Co.**, 175 Wyman St., Waltham 54, Mass. B

Circle 652 on Page 19

Generator

generates near-linear and angular acceleration motion

Angular acceleration generator generates closely controlled angular and near-linear acceleration motion. Intended for use as a laboratory instrument, unit also has production applications. It imparts sinusoidal angular motion to a test table by means of a cylindrical rotor motor, with single-phase, two-pole winding placed at right angles to a dc field. Function generator and power amplifier provide an ac source variable in frequency down to dc, with means of adjusting gain of system. Driver is housed in cast-iron frame to reduce resonances; power sup-



plies, amplifier, and function generator are mounted in a relay rack cabinet. **Statham Development Corp.**, 12411 W. Olympic Blvd., Los Angeles 64, Calif. L

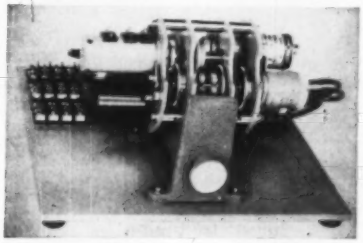
Circle 653 on Page 19

Breadboarding Equipment

makes wide variety of 2⅞-in. diam mechanisms

New equipment for breadboarding and test of servo and instrument

mechanisms consists of stocked components which can be assembled quickly into a wide variety of 2⅞-in. diam mechanisms. As many as six synchro-style components of any pilot diameter can be mounted. Standard gear ratios range from 1:1 to 78,125:1, and antibacklash gearing is available in all ratios. A 48-terminal breadboard mounting assembly clamps test mechanism with a thumb nut and permits convenient component interwiring. Gears are AGMA Precision 1 or better, inertias are low, and bearings are ABEC 7, double shielded.



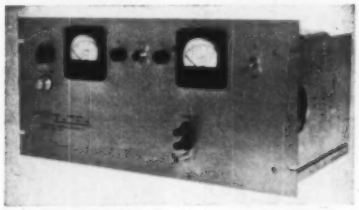
Equipment meets requirements of MIL-E-5400. **Precision Mechanisms Corp.**, 577 Newbridge Ave., East Meadow, N. Y. D

Circle 654 on Page 19

Power Supply

delivers 10 to 14.5 v dc at up to 15 amp

Model TPS-1 transistorized power supply is designed to replace storage batteries in the laboratory. From 100 to 130 v ac input, unit delivers 10 to 14.5 v dc at up to 15 amp, regulated within 0.2 per cent over full input voltage and output current ranges. The rack-mounted unit incorporates a high-volume blower which forces air across the heat-sink area, ensuring low operating temperatures for

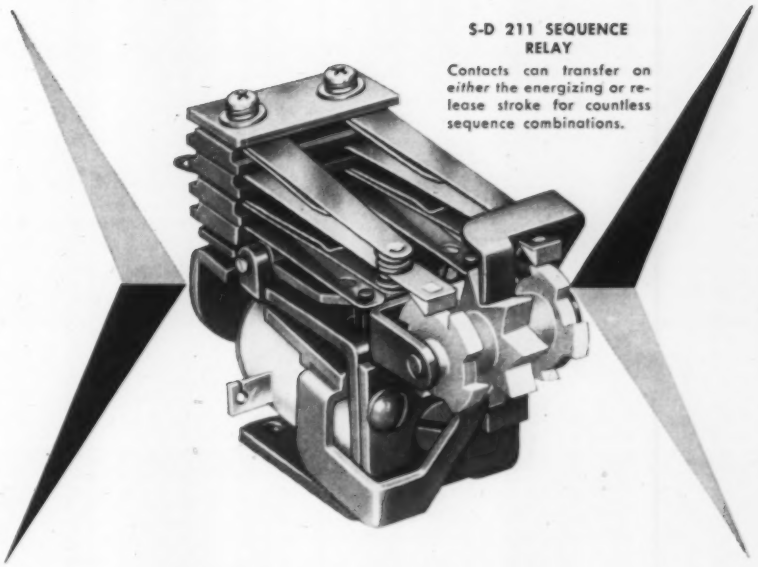


maximum reliability and component life. **Southwestern Industrial Electronics Co.**, 2831 S. Post Oak Rd., Houston, Tex. I

Circle 655 on Page 19

S-D 211 SEQUENCE RELAY

Contacts can transfer on *either* the energizing or release stroke for countless sequence combinations.



HERE'S REAL SEQUENCE VERSATILITY

. . . backed by absolutely positive operation

You can get a million operating sequences from this little relay . . . including a lot of unusual ones that previously required much more complicated control systems. For instance, the optional feature of contact transfer on the de-energizing stroke of the armature has provided simple, low-cost schemes for alternating pump and compressor operations. In addition, of course, Struthers-Dunn 211 Relays find wide use in automatic process and machine tool control, traffic control, door and window openers and the like.

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Circle 504 on Page 19

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Topics included, are small-signal theory, linear techniques of analysis, phase-plane analysis, frequency response, statistical methods, and logic circuits.

Fluid Mechanics, Second Edition. *By Victor L. Streeter, Professor of Hydraulics, University of Michigan; 480 pages, 6 by 9 in., clothbound; published by McGraw-Hill Book Co. Inc., 330 West 42nd St., New York 36, N. Y.; available from* MACHINE DESIGN, *$7.50 per copy postpaid.*

The second edition of this book has been divided into two parts. The development of equations and concepts, and their use in simple applications, are covered under Fundamentals of Fluid Mechanics.

Part two, Applications of Fluid Mechanics, deals with the complex applications to flow measurement, hydraulic machinery, pipe systems, open-channel flow, principles of control systems, and oil hydraulics.

Gas Turbine Materials. *By G. Lucas and J. F. Pollock; 163 pages, 5½ by 8½ in., clothbound; published by The Macmillan Co., 60 Fifth Avenue, New York 11, N. Y.; available from* MACHINE DESIGN, *$5.75 per copy postpaid.*

This book is a survey of high-temperature materials and their application to gas turbines. Problems, such as how the thermodynamic design of gas turbines affects the choice of materials, how fuels in-

fluence operating conditions and material selection, and the phenomenon of creep and stress-temperature effects, are discussed with emphasis placed on design aspects.

Applied Mathematics for Engineers and Physicists, Second Edition. *By Louis A. Pipes, Professor of Engineering, University of California at Los Angeles; 723 pages, 6 by 9 in., clothbound; published by McGraw-Hill Book Co. Inc.; 330 West 42nd St., New York 36, N. Y.; available from* MACHINE DESIGN, *$8.75 per copy postpaid.*

The mathematical concepts treated in this book pertain to engineering problems which arise in structures, dynamics, vibration analysis, system design, and electronics.

Covering many topics in the advanced calculus field, subjects discussed include infinite series, Fourier analysis, Laplace-transform theory, matrices, and nonlinear-differential equations.

New Standards

American Standards. *Each publication is 8½ by 11 in., paperbound, and stapled; published by and available from The American Society of Mechanical Engineers, 29 West 39th St., New York 18, N. Y.*

ASA B16.15-1958. Brass or Bronze Screwed Fittings, 125 lb. *15 pages; $1.50 per copy.*

This revised standard covers pressure ratings, sizes and methods of designating openings of reducing fittings, marking, minimum requirements for materials, dimensions and tolerances, and threading of 125 lb brass or bronze screwed fittings.

ASA B18.9-1958. Plow Bolts. *12 pages; $1.50 per copy.*

This revised standard recommends the use of two plow bolts for new designs, and includes standards on four others. Also included as supplementary information are the dimensions of two nonstandard bolts.

New Codes

Power Test Codes. *Each publication is 8½ by 11, paperbound, and stapled; published by and available from The American Society of Mechanical Engineers, 29 West 39th St., New York 18, N. Y.*

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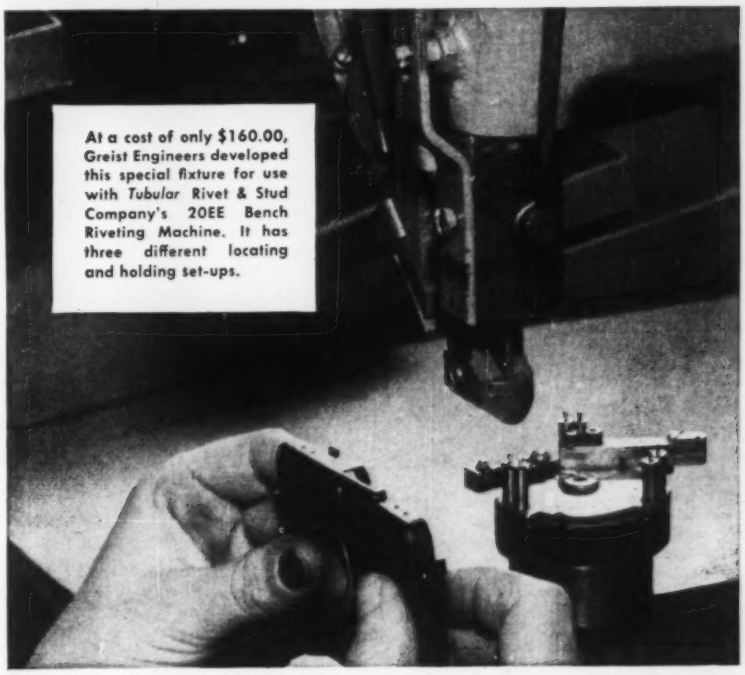
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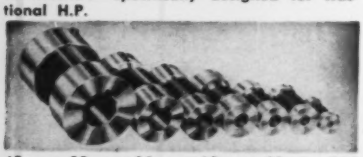

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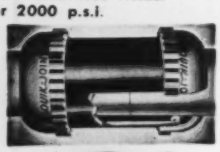

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Circle 507 on Page 19

PTC 25-1958. Safety and Relief Valves. 31 *pages; $2.50 per copy.*

This code establishes rules for conducting tests of spring-loaded, weight-loaded, and pilot-operated safety and relief valves. The code is limited in flowing mediums to steam, gases, and liquids in non-flashing states.

PTC 19.12-1958. Measurement of Time. 12 *pages; $1.50 per copy.*

This Supplement 12 on Instruments and Apparatus covers units of time, accuracy of timekeepers, and time-telling mechanisms.

PTC 19.14-1958. Linear Measurements. 14 *pages; $1.50 per copy.*

This Supplement 14 on Instruments and Apparatus gives the description, use, limitation, and accuracy of the various linear-measurement devices.

Association Publications

Man, Metals and Modern Magic. *By J. Gordon Parr; 231 pages, 5 by 7½ in., clothbound; published by and available from American Society for Metals, 7301 Euclid Ave., Cleveland 3, Ohio; $2.95 per copy.*

This book tells the story of what metals have done to shape man and his activities from 4000 B.C. to the 20th century. Although primarily historical, considerable information is included on the extraction, refining, and use of metals. This survey of metals through the ages points out trends which will affect future use of metals.

Manufacturers' Publications

Aids to Efficient Machine Design in Welded Steel. 92 *pages, 8½ by 11 in., paperbound; published by and available from The Lincoln Electric Co., 22801 St. Clair Ave., Cleveland 17, Ohio; $1.00 per copy.*

This manual contains information for improving machine design through the use of welded steel. Techniques, charts, nomographs, and data are presented for various aspects of design, including bending loads, torsion, vibration, and load conditions.

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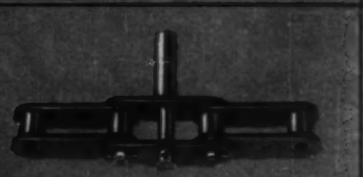
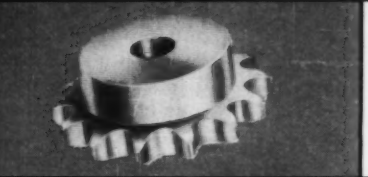
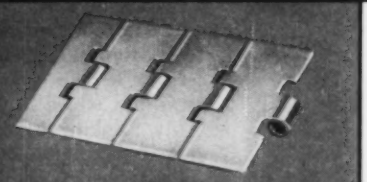
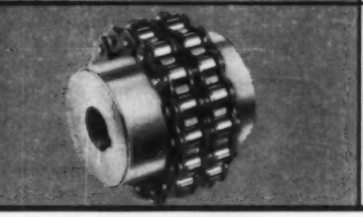
SPECIAL ROLLER CHAIN		Extended pitch, cable or sling chains, attachment chain or special chains to specifications. Atlas makes them all and stocks many sizes for quick deliveries.
PRECISION FITTED SPROCKETS		Complete line of precision made roller chain sprockets to A.S.A. specifications ⅜" pitch through 2" pitch carried in stock. Available in heat treatable steel, bronze, Electrolized and stainless steel.
CONVEYOR CHAIN		Atlas FLAT-VEYOR Chain and sprockets. Complete line of both Electrolized and carbon steel carried in stock. Also available in stainless steel upon order.
FLEXIBLE COUPLINGS		Complete line of steel chain couplings, carried in stock. Stainless steel, bronze and Electrolized are available made to order.

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Professional Viewpoints

. . . a stronger profession . . .

To the Editor:

Your editorial, "For a Stronger Profession," (MACHINE DESIGN, May 1, 1958) expresses ideas with which I agree fully. Your quoting of Dr. Condon's comparison of the engineering profession with the medical profession is one that is often made. There is one thing lacking in engineering that the medical profession has: A recognized and respected group of assistants, the nurses.

Along with the building of a smaller, yet well-respected engineering profession, I think that we will have to have a recognized technical group of men who are the engineers' assistants. Our technical institutes are trying to do this, but even with their efforts, technicians are still not recognized in nearly the manner that the nursing profession is recognized.

What I am suggesting is almost exactly the same thing that came out in the "Grinter" report a few years ago concerned with the bifurcation of engineering curricula. This was voted down vehemently, even though we in the teaching profession know, and you certainly do know too, that we are graduating men from college on a double standard. We all recognize that some of our men are far superior to others in spite of the fact that they get exactly the same degree. These men who are not so good, yet have been able to pass their college work, are the ones that really fit into the assistant area. Even though we don't say it and we don't write it, they actually end up this way. Your editorial suggests excluding these men from membership in the engineering profession, but offers no substitute, which I think we do need.

My thinking is influenced by the European system of having both technicians and engineers.

Perhaps in the near future we will see some changes in the training in colleges, particularly in the requirements of the men who graduate. With college entrance becoming tighter and tighter, I am sure that the men who graduate will be the men who enter with better preparation and with more ability. Perhaps this will automatically restrict the engineering profession to graduate engineers who have completed all the requirements to be an engineer in the interpretation you give.

With the demand for college degrees for everyone, should we take the suggestion of awarding a degree at the end of two years?

No matter how the separation of technicians and engineers will be effected, we still need to have recognition for this intermediate professional group which will be to the engineering profession what nurses are to the medical profession.

So I am all for your suggestion, and I do think that we need to emphasize the respect and recognition that is needed in order to make people want to serve as technicians.

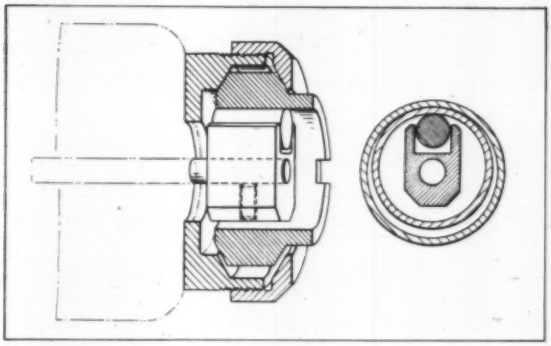
W. B. DIBOLL
Washington University

NOTEWORTHY

Patents

Adjustable-Speed Friction Drive

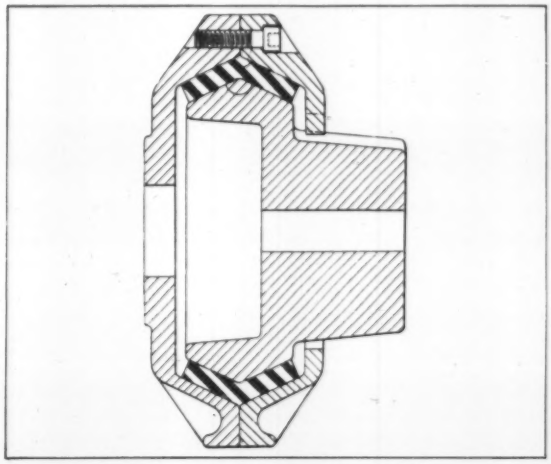
Speed reduction in an epicyclic drive is provided by rolling-frictional engagement of one cylindrical element inside another. Input to the reduction unit is



by means of an orbiting roller held loosely in a slotted rotating block on the drive shaft. Output sleeve, which rolls on a mating raceway inside the fixed housing, can be translated axially by a threaded cap to change the radius of rolling contact and, therefore, the speed reduction. *Patent* 2,831,373 *assigned to Graham Transmissions Inc., Menomonee Falls, Wis., By William B. Weis.*

Flexible Coupling

Transient shaft deflections in axial, radial, or angular directions are accommodated by an inexpensive flexible coupling. Component parts of the unit are convex and concave double cones, separated by a compressed rubber filling. Loose spline connection between coupling halves prevents complete separation of the con-



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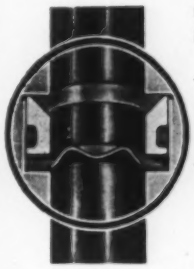

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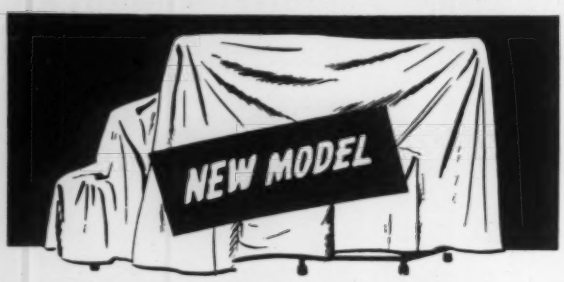

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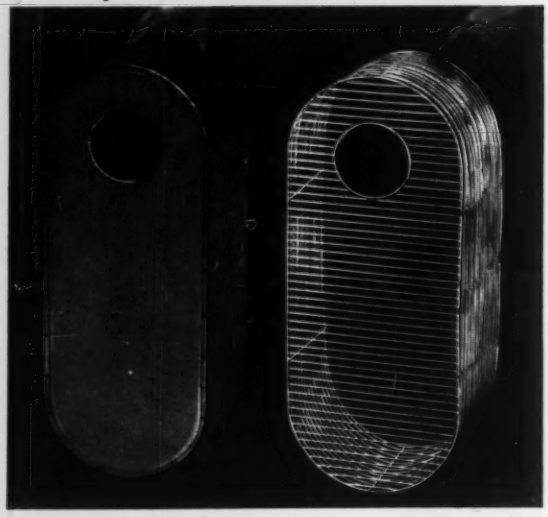

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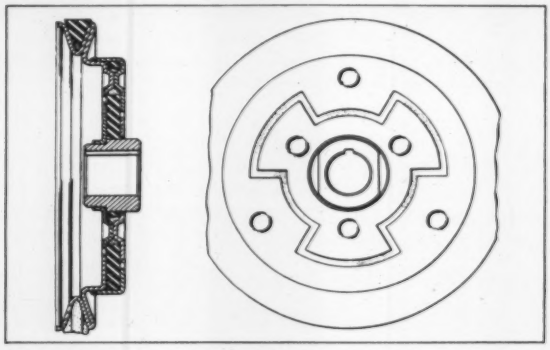
Dept. 3311, 67 Clinton Street, Binghamton, N. Y.

nected shafts should the rubber member fail. *Patent 2,822,676 assigned to Metalastik Ltd., Leicester, England, by Marcus Horovitz.*

Vibration-Damping Pulley

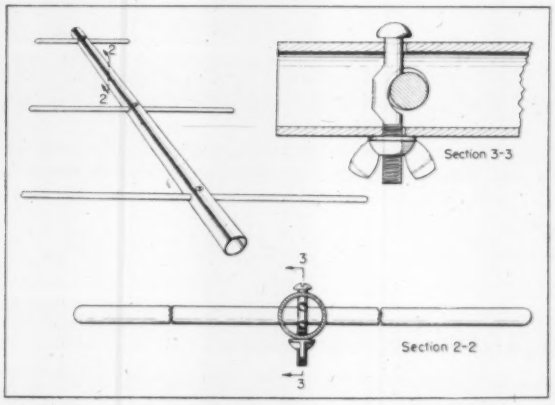
Vibrations are absorbed by a rubberized-fabric core in the web of a pulley assembly. Pulley and adjacent structure are stampings joined by welding. Web stamp-



ings enclose the core, which is perforated at the welded spots. Clearance between web tongues allows distortion of core material but limits angular displacement between pulley-assembly parts. *Patent 2,828,616 assigned to General Motors Corp., Detroit, by Philip B. Zeigler and Robert P. Rohde.*

Right-Angle Tube Joint

Right-angle assembly of tubes of different diameters is simplified by a bent-bolt fastener. Bolt, which is



mounted transversely in the larger tube, has a U-shaped bend to receive the smaller tube. Tightening a wing nut on the bolt produces a wedging action to lock the assembly. *Patent 2,831,717 assigned to Simplicity Tool Co., Portland, Oreg., by Joe L. Mayer.*

Copies of patents briefed in this department may be obtained for 25 cents each from The Commissioner of Patents, Washington 25, D. C.

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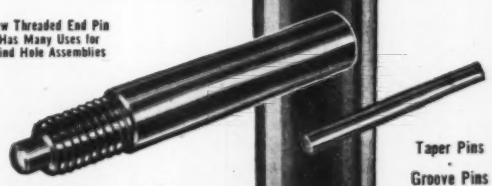

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Circle 513 on Page 19

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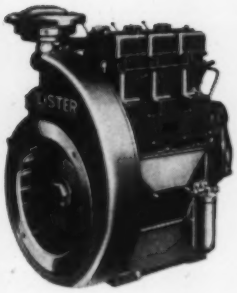

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Readily available parts and service. Write us your requirements and for data and prices.

LISTER-BLACKSTONE, INC.

42-32 21st St., Long Island City 1, N. Y. Tel.: STillwell 6-8202

In Canada: Canadian Lister-Blackstone, Ltd., 1921 Eglinton Av., E. Toronto 13, Ont.

Circle 517 on Page 19

flat, square, rectangular, shaped Stainless Wire by WEBB

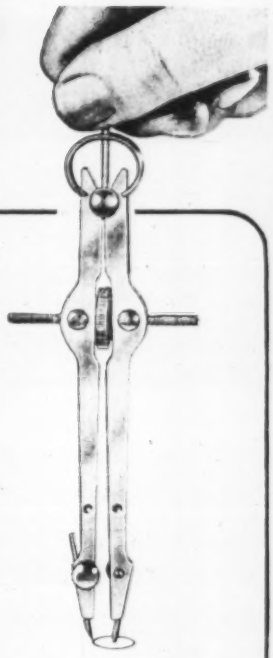
• Piston rings, springs, instruments and component parts . . . any product where performance must be good . . . will be better with WEBB.

WEBB WIRE Division of The CARPENTER STEEL CO. New Brunswick, N. J.

Circle 518 on Page 19

VEMCO

COMPASSES PASS THE "TWIST TEST"



Here is a simple, effective test to show whether or not a compass has the strength and rigidity necessary for the "heavy-duty" demands of modern drafting-room practice. Draw black circles one-half inch in diameter with hard lead in compass, applying heavy twisting pressure. The legs must not twist. Precision made VEMCO compasses pass this test perfectly, because of their welded steel construction, and unique "OPEN-TRUSS" design.

Send for free compass catalog

VEMCO
Drafting Equipment of Quality

V. & E. Manufacturing Co.
Department AM-5
P. O. BOX 950-M PASADENA, CALIFORNIA

Circle 519 on Page 19

Metron MINIATURE VARIABLE SPEED DRIVES

- Complete
- Adaptable
- Compact

- ✓ High speeds up to 10,000 RPM on either shaft
- ✓ Small—to fit into your product
- ✓ Permanently lubricated
- ✓ Lever, worm gear, spur gear, push rod, thumb screw or miter gear adjustment
- ✓ Output up to .025 HP

Get variable speeds from 1-5 increase through 1-1, to 5-1 decrease! Just move the control to desired speed ratios (calibrated on top) and the miniature variable instantly produces the speeds you need in your product!

Write for Bulletin No. 99

Metron INSTRUMENT COMPANY
442 Lincoln St., Denver 3, Colo.
DISTRICT OFFICES • NEW YORK • CHICAGO

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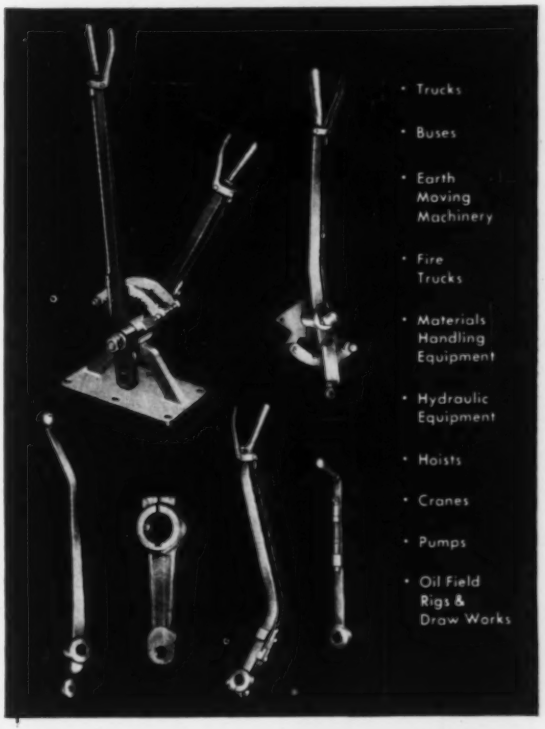
BATAVIA LEVERS

for machines and vehicles



standard, stocked forgings quickly assembled to order

NO SPECIAL ENGINEERING: Chances are there's a Batavia lever design that's either ready-made for your requirements or can be easily modified to fit the need.

NO SPECIAL FABRICATION: To meet an almost limitless number of design requirements without special dies and tooling, Batavia has developed *and stocks* an extensive line of standard upper and lower half assembly forgings, hubs, sub-levers and extensions. With all parts interchangeable, any upper half assembly forging may be joined with any lower half assembly forging or any sub-lever forging to produce the lever desired.

CONTROL UNITS, TOO: In addition to its full line of levers and lever assemblies, Batavia Metal Products also manufactures winch and transmission controls.

GET FULL DETAILS by mailing the coupon below.

BATAVIA METAL PRODUCTS CORP.
Batavia 2, New York

Mail your illustrated Lever Bulletin to us, without obligation.

NAME TITLE

COMPANY

ADDRESS

CITY ZONE STATE

Circle 521 on Page 19

no need to design new RUBBER molds and dies!

choose from Atlantic India's

thousands of rubber molds and dies

A 39 year accumulation of molds and dies are now on hand at Atlantic India, ready to serve you. Chances are one of our standing molds or dies will fit your needs.

If it happens that your application calls for a unique rubber product we have years of "know-how" at your command. What ever your need, washers, gaskets, molded parts, extrusions, sheet or sponge rubber, Atlantic India is ready to serve you.

SEND TODAY!
Catalog No. 52
185 pgs. showing thousands of diagrams

Atlantic India Rubber Wks., Inc.

Producers of the AIRWIN line of Rubber Products

573 West Polk St., Chicago 7, Illinois

DRIV-LOK STUDS

Save 60% Fastening Time!

- HOLD PERMANENTLY
- DISASSEMBLED EASILY WITHOUT DAMAGE TO COMPONENTS

Quick, simple insertion . . . Drill Hole and Drive Stud with a single blow.

TYPICAL APPLICATIONS

Attaching name plates or instruction panels

Fastening spring assemblies or control arms.

Widely used for fastening brackets.

Securing semi-permanent covers and closure plates.

3 HEAD STYLES

Round (standard) Flat (to order) Countersunk (to order)

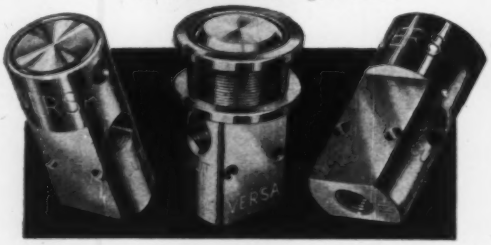
Driv-Lok Studs save time and reduce costs in fastening name plates, covers, brackets, panels, etc, to heavier sections and for countless other applications involving light-to-heavy member fastening. Once installed, Driv-Lok Studs will not vibrate loose or fall out — yet they can be easily removed without damage to components. Made in 3 head styles. Write for illustrated catalog sheet, prices and samples.

DRIV-LOK SALES CORPORATION
715 Park Avenue • Sycamore, Illinois

Circle 523 on Page 19

Versa "A" Valves

Give MAXIMUM Capacity In MINIMUM Space...



- Versa solves the space problem with a truly economic valve.
- The overall size of the Versa "A" valve is only 2" high by 1" in diameter, yet it has the capacity of much larger valves.
- Ideal for controlling cylinders, instruments and larger pilot valves.
- Available in ⅛" NPT in 2-way & 3-way types with or without button guard, in either normally open or closed models.
- Simple to mount on equipment or can be furnished for panel mounting.
- Prices range from $4.00 to $6.50 each. For complete information write today for Folder #14S.

VERSA

VERSA PRODUCTS COMPANY INC.
247 SCHOLES STREET, BROOKLYN 6, N.Y.

FREE CATALOG! Write today for your free copy of Versa's Catalog #14.

Circle 522 on Page 19

Circle 524 on Page 19

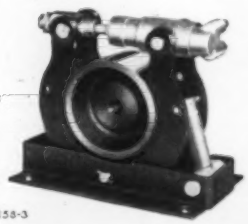
new 6"x3"

WAGNER HYDRAULIC BRAKE SYSTEM

Provides sure stops for smaller cranes

Wagner now offers a new 6" x 3" size hydraulic brake to provide the correct braking system for floor operated pendant controlled cranes, monorail cranes or small cab operated cranes. These hydraulic brakes will stop your cranes safely . . . easily . . . economically.

Let your nearby Wagner Sales Engineer help you put the *right* braking system on your small or large cranes—let him help you with tension control or hydraulic actuating problems—call him today, or write for Wagner Bulletin IU-226.



W158-3

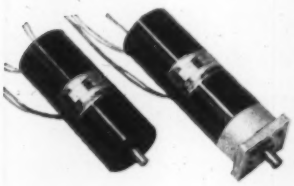
Wagner Electric Corporation
6404 PLYMOUTH AVENUE, ST. LOUIS 14, MO., U. S. A.

Circle 525 on Page 19

NEW A.C. GENERATORS miniature drag cup type

give precise linear output at modest cost

New Globe a.c. drag cup type "tachometer" generators are designed specifically for rate or speed control applications which require extreme accuracy without excessive cost. They meet pertinent military specifications.



Outputs are linear to within ±0.5% of speed up to a rate of 4.5 v/thousand or up to 16.2 v. max. at 3600 rpm. At normal sensitivity of 1.5 v/thousand rpm, null voltage indication is 0.02 v. RMS fundamental. Null voltage increases proportional to voltage sensitivity. Various windings are available to meet excitation requirements. Modifications are easily made to meet your requirements, up to inputs of 115 v., 60 cycle, and up to 200 v., 400 cycle.

Units illustrated consist of a Globe type FC drive motor, coupled integrally with a generator, with and without a precision planetary gear reducer. Such complete packages can be quickly engineered and manufactured by Globe Industries from a wide selection of pre-designed or inventoried components. Geared a.c. generator package above is 6.5" x 1.675" in dia.; weight is about 24 oz. Write for technical bulletin.

GLOBE

Globe Industries, Inc.
1784 Stanley Avenue, Dayton 4, Ohio

Circle 526 on Page 19

SANDSTEEL SPRINGS

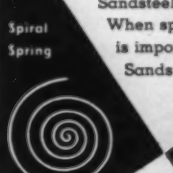
GREATER POWER MORE CONSTANT POWER

For Many Applications

If you are looking for a power spring for any of dozens of applications, look to Sandsteel for your needs. Whether your application calls for the common spiral spring or the unique SANDSTEEL crosscurved spring for either stronger or more constant power, Sandsteel can solve your spring needs.

In its more than 30 years' history, Sandsteel has developed many tools and dies that are adaptable to various types of power spring manufacturing. The presence of this equipment cuts down the tooling costs to the customer when Sandsteel handles the job. When spring performance is important, specify Sandsteel.

Spiral Spring



Crosscurved spring in free condition

Crosscurved spring in housing

If your spring requirements are for any of the applications listed below, or similar applications, call on Sandsteel.

BALANCERS
Doors
Lamps
Tools

CAMERAS
Mainsprings
Shutter Springs

ELECTRICAL INSTRUMENTS
Gyroscopic Controls
Meters
Potentiometers
Servo Mechanisms

JEWELRY
Belts
Bracelets
Pins

OFFICE MACHINES
Billing Machines
Calculators
Computers
Portable Tape Recorders
Printers
Typewriters

RECOIL STARTERS
Chain Saws
Lawn Mowers
Outboard Motors

RETURN MECHANISMS
Balance Reels
Drill Press Quills
Electric Saw Guards
Fishing Reels
Tape Dispensers
Telephone Dials

SAFETY DEVICES
Burglar Alarms
Fire Alarms

TENSION DEVICES
Brush Holders
Gear Trains

TIMING DEVICES
Chart Recorders
Clocks
Fuzes
Parking Meters
Timers
Watches

MISCELLANEOUS
Toys
Vending Machines

Write for free literature and case history files.

SANDVIK STEEL, INC.
Sandsteel Spring Division
Fair Lawn, New Jersey
SWarthmore 7-6200
In New York: ALgonquin 5-2200

SS-144

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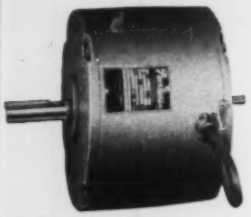
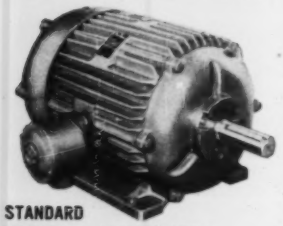
ONLY ONE MOTOR IS RIGHT FOR YOUR APPLICATION...

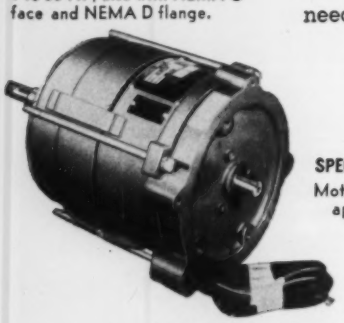
SPRAY-TIGHT
Fan cooled; 7½ HP; Navy; Hi-shock to Navy Spec. MIL-M-17060A.



TOTALLY ENCLOSED
Blower and Drive Motor; 4 HP; air drawn over motor.



STANDARD EXPLOSION-PROOF MOTOR
1 to 30 HP; also with NEMA C face and NEMA D flange.



SPECIAL CONSTRUCTION
Motor to fit customer's application design.

• One thing's certain—just one motor is right for your application. Design engineers turn to Peerless more often than ever today because Peerless is equipped to produce the motors that power their machines best. There's no need to fit the machine to the motor. Peerless has hundreds of motor designs—many of them created specifically to meet OEM problems. Give your next motor problem to the Peerless Representative near you or write directly to the factory. We'll work with you to develop the one motor that meets your needs best.

ELECTRIC MOTOR DIVISION
THE Peerless-Electric® COMPANY
FANS · BLOWERS · MOTORS
1520 W. MARKET ST. • WARREN, OHIO

Circle 528 on Page 19

First choice of the rocket and missile industry...

Three superlative Marsh products are widely used and approved by the aircraft and missile industry:

MARSH Pressure Gauges...
because they combine the most advanced features ever found in pressure, vacuum and compound gauges. There is a Marsh Gauge for every conceivable application.

MARSH Needle Throttling Valves...
because they are guaranteed to give micrometer regulation at HIGH pressures—pressure up to 10,000 psi—and any temperature up to 500° F.

MARSH Dial Thermometers...
because they offer the precision and accuracy a precision industry demands. Most complete line; wide temperature ranges, dial sizes, patterns, finishes.

All Marsh products available with AND threads

MARSH *New catalog covers all details*

MARSH INSTRUMENT CO. *Sales Affiliate of Jas. P. Marsh Corp.* **Dept. B, Skokie, Ill.**
Marsh Instrument & Valve Co., (Canada) Ltd., 8407 103rd St., Edmonton, Alberta, Canada. Houston Branch Plant, 1121 Rothwell St., Sect. 15, Houston, Texas

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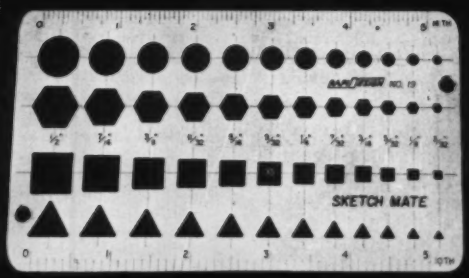
no. 19 **SKETCH MATE** *template*



$1.50 AT YOUR LOCAL DEALER

The Rapidesign No. 19 Sketch Mate Template is one of more than 100 Rapidesign Time-Saver Templates—all of which are better made, more useful and lesser priced.

CATALOGUE NO. 60 AVAILABLE UPON REQUEST

RAPIDESIGN INC.
P. O. BOX 429, BURBANK, CALIFORNIA

Circle 530 on Page 19

TWO NEW MINIATURE GRIPCO FASTENERS

FOR

- **Hard to reach assemblies**
- **Thin metal applications**
- **Automatic feeding**
- **LOW COST fasteners**

Gripco Miniature Pilot Weld and Clinch Nuts, with or without the famous Gripco locking feature, provide low cost fastenings in blind assemblies or as extra threading depth for thin metals. Miniature size ideal where space is limited. Sizes #4 through ¼" in Miniature Series, fine and coarse threads. Sizes ¼" through ⅝" are available in standard dimensions.

Large inventories carried for immediate shipment. Brass and Aluminum made to special order.

Write for samples and full details.

GRIP NUT COMPANY
103 Maple Ave.
South Whitley, Indiana

120

Circle 531 on Page 19

learn the facts of FELT

See how **felt** fits in with your products!

Let us show you how to save money and increase efficiency with the proper use of felt.

FREE Samples and Applications of Industrial Felt.

*made to S.A.E. and Federal Govt. Specifications

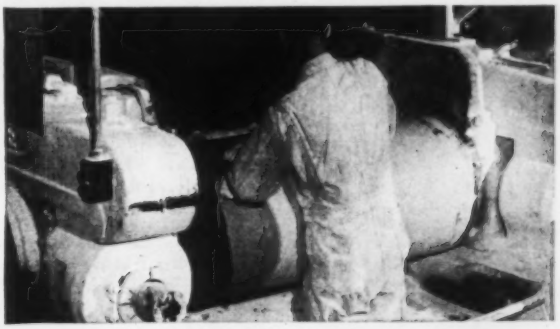
CONTINENTAL FELT COMPANY, INC
22 WEST 15th STREET NEW YORK 11, N. Y.

Circle 532 on Page 19

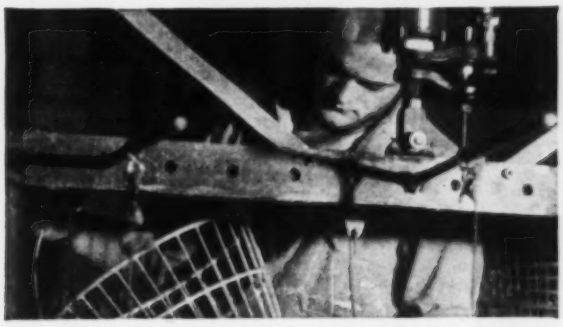
want ask *Any Rubber Problems Solved?*

A Member of the M-R Family

For Parts of Silicone Rubber . . . Silicone Rubber Division. For extreme temperature durability, for dielectric and chemical qualities, silicone is today's wonder rubber. Minnesota Rubber's Silicone Division has had seven years experience with the injection molding and extrusion of silicones.



For Color in Rubber . . . Rainbow Rubber Division. To brighten a housewife's new kitchen or to identify an industrial rubber part, Rainbow Division combines bright, durable color with dependability and toughness. Need a colorful rubber? Rainbow Rubber Division can help you.



For Versatility in Rubber . . . Plastics and Latex Division. Working in the field of polyvinyl chlorides, this division has developed new techniques which solve dipping, forming and coating problems more easily, effectively and economically. These men are experts in dipping and liquid molding techniques.

Write for the 16-page brochure describing Minnesota Rubber's facilities, also for full information about how Minnesota Rubber can help solve your production problems. Minnesota Rubber Company . . . originators of modern rubber injection molding and PROTOTYPES by KOTOKAST®.

MINNESOTA RUBBER COMPANY
Dept. 809, 3630 Wooddale Ave., Minneapolis 16, Minn.

Circle 533 on Page 19

Does specialized business publication advertising help salesmen?

No one is in a better position to give a hard-boiled, practical answer to this question than the men who spend their working lives on the sales front... the men the ads are supposed to help... the men who sell.

Here is the statement of a salesman who knows what advertising does for him when it appears in the industrial, trade or professional publications that serve the specialized markets to which he sells:

says Mr. Beach:

W. A. Beach
Black & Decker Mfg. Co.
sells to wholesalers and retailers

"We have to sell our product first to the wholesaler; then help him sell to the retailer. We do a lot of missionary work. We make calls with the wholesaler salesmen and we run dealer and clerk training clinics in which we try to help the dealers improve their merchandising.

"Our trade advertising in publications read by the wholesaler and dealer, works with us along those same lines. In other words, it's like having an additional sales representative in each territory constantly calling on the dealers and wholesalers. Every time they open their trade books he tells them about our products and the special promotions we run to help them sell more. He works nights too, and calls on them at home when they're doing their reference work and planning. I know they do take their magazines home at night and read them. So, in effect, this 'salesman' works at night for us, and I do believe he finds them in a more receptive mood at that time.

"The greatest evidence that our advertising is out there doing a job and really paying off is in connection with the two large-scale promotions we do each year.

"For instance, right now we're working on our current Christmas promotion called 'The Bell-Ringer'. That was announced in September. Between the announcement and the Christmas selling season we must sell the wholesaler and then set up a schedule with each wholesaler to go out with his men and call on the trade and actually sell the deal to the retailer. You can imagine how tight our schedule is. In this short span of time we have to call on practically every hardware dealer in the territory. It adds up to a terrific number of calls and in order to get around, we just can't afford to give each dealer all the time we'd like to. In addition, it's extremely difficult to explain all the details on something like this Christmas promotion in the short time allotted each dealer.

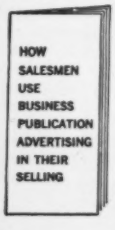
"We couldn't do it if the advertising wasn't in there doing part of the work for us. Believe me, it's wonderful to find that when you do call on a wholesaler or dealer you don't have to take the time to explain all the details, because he has already read about it in the hardware publications. In most cases he's ready to see the merchandise. We have the opportunity to close the sale in short order. Right now I'm engaged in making dealer calls with wholesalers' salesmen and I'd say that nine cases out of ten the dealers have already seen our ads on the Christmas promotion and are somewhat pre-sold on the deal. In fact, in most cases I've found that all I have to do is show him the merchandise."

Ask your own salesmen

what your company's business publication advertising does for them. If their answers are generally favorable, you can be sure that it is really helping them sell. If too many answers are negative, it could well pay you to review your advertising objectives—and to make sure the publications that carry your advertising are read by the men who must be sold.

How salesmen use their companies' advertising to get more business

Here's a useful package of ideas for the sales manager, advertising manager or agency man who would like to get more horsepower out of his advertising. Send for a free copy of the pocket size booklet which reports the successful methods employed by eleven salesmen who tell how they get more value out of their companies' business publication advertising.



You can be sure that more of your salesmen will use your advertising after they read how others get business through these simple methods.

The coupon is for your convenience in sending for your free copy.

NATIONAL BUSINESS PUBLICATIONS, INC.

NBP

...each of which serves a specialized market in a specific industry, trade or profession.

NATIONAL BUSINESS PUBLICATIONS, INC.
Department 11E
1413 K Street, N. W.
Washington 5, D. C. **STerling 3-7533**

Please send me a free copy of the NBP booklet "How Salesmen Use Business Publication Advertising in Their Selling."

Name _____

Title _____

Company _____

Street Address _____

City _____ Zone _____ State _____

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MACHINE DESIGN

Penton Building, Cleveland 13, Ohio
Main 1-8260

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Business Manager

MARY L. CALLAHAN
Advertising Service Manager

RICHARD A. TEMPLETON
Research and Circulation Manager

ROBERT E. LESSING
Production Manager

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Murray Hill 2-2581

Simsbury, Conn. .....17 Deerfield Lane
ALAN C. BUGBEE
Oldfield 8-4764

Dresher (Philadelphia), Pa. ....1335 Harris Rd.
CHANDLER C. HENLEY
Mitchell 6-2585

Cleveland 13 .....Penton Bldg.
JACK W. WALTON, DON J. BILLINGS
Main 1-8260

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CHARLES F. REINER
Broadway 3-8150

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HOWARD H. DREYER, ROBERT Z. CHEW
DONALD A. IVINS
Whitehall 4-1234

Los Angeles 36 .....5943 West Colgate Ave.
F. J. FULLER
Webster 1-6865

San Francisco 4 .....57 Post St.
Robert W. Walker Co.
Sutter 1-5568

Griffin, Ga. .....1106 Pine Valley Rd.
FRED J. ALLEN
Griffin 7854

London, S.W.1 .....2 Caxton St., Westminster

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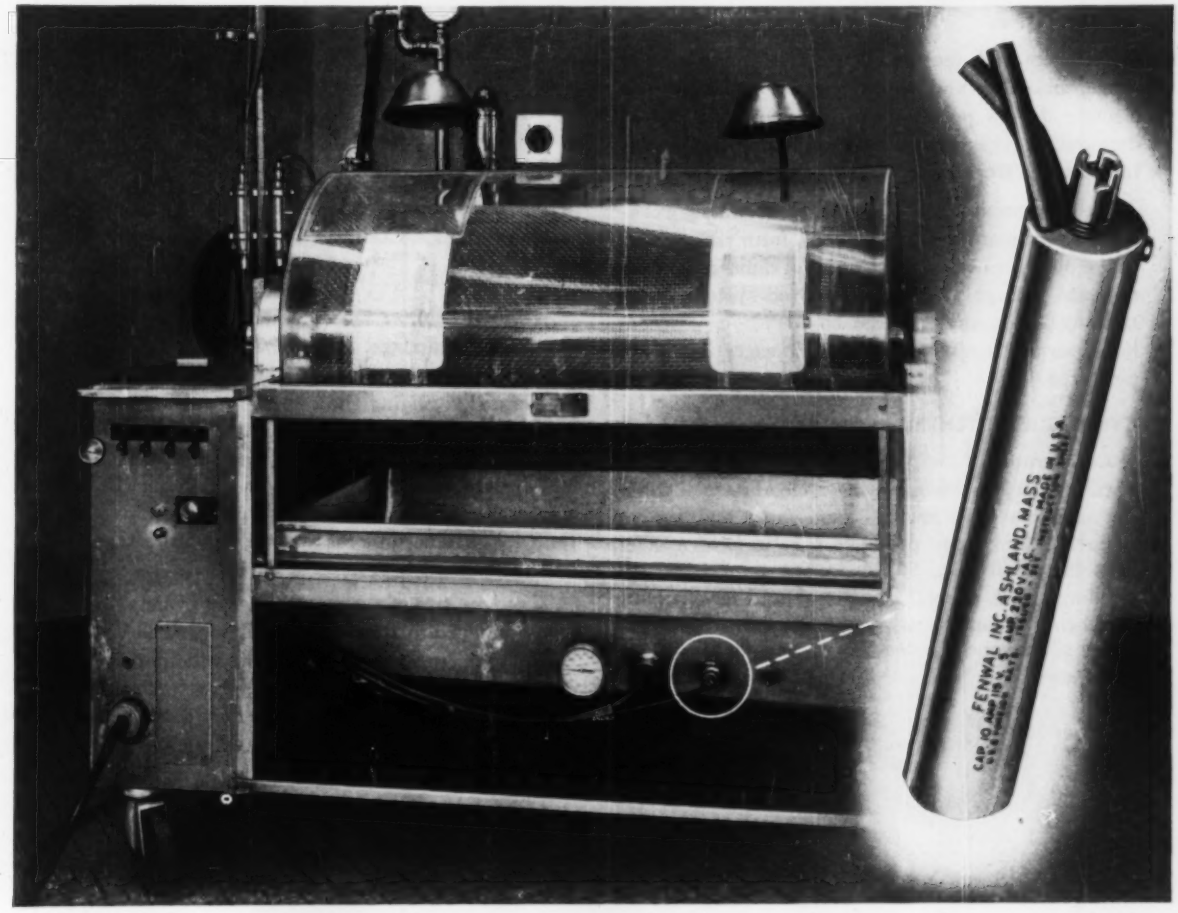

Fenwal CONTROLS TEMPERATURE . . . PRECISELY

APPLYING RELIANCE V*S DRIVES IN CYCLING EQUIPMENT

BY
V. R. MURPHY, E.E.
Manager of V*S Products
Reliance Electric and
Engineering Company

Years of application experience have proved Reliance V*S Drives are ideal for powering cycling equipment. The all electric design is fast acting, acceleration times in tenths and hundreds of a second are common. V*S equipment lends itself to a variety of automatic controls.

V*S DRIVE COMPONENTS

A V*S Drive operates from standard a-c. power lines and consists of three basic components: d-c. drive motor, packaged motor controls and operator's control station.

Reliance drive motors change speed over a wide range, smoothly and without speed steps. The all electric design permits the inclusion of built-in dynamic or regenerative braking, giving fast, maintenance-free stopping power.

Motor-generator sets or electronic rectifiers, working from in plant a-c. power lines, form the nucleus of the motor control unit. A series of built-in controls regulate voltage and current in the system. With these controls, any required combination of speed, horsepower, torque and time characteristics are produced.

CYCLING WITH TENSION CONTROL

An example of simple, rapid cycling is shown in Figure 1. This is the operating cycle of a small winding machine that rewinds wax paper and similar material from large production rolls onto smaller rolls for retail sale. The operation requires a fast winding speed, as well as a slow speed for changing retail rolls. After the new roll is started, the productivity of the machine depends on how fast it can get to winding speed without tearing the material.

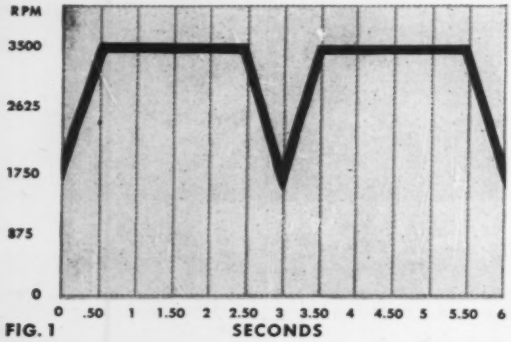

FIG. 1

A Reliance VST Control is used to force motor voltage to give optimum acceleration and deceleration rates. Selected rates can be designed into equipment to meet any cycling requirement. A description of this machine is found in Bulletin D-1532.

FORWARD AND REVERSE CYCLING

Another type of cycling operation is shown in Figure 2. This shows the cycle pattern of a flying cut-off on a continuous pipe mill. A V*S Drive automatically, measures the pipe length, starts the cut-off carriage and brings it to line speed, stops after cut-off and returns the carriage for another cut.

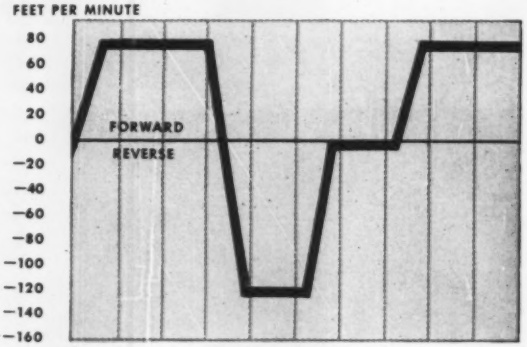

FIG. 2

A digital counter measures the pipe as it passes through the carriage. When the correct length has been fed through, the motor is forced and rapidly accelerated, bringing the carriage up to line speed. Using a dual tachometer matching system and a VSR speed regulator, the carriage speed is exactly matched to line speed during cut-off. After cut-off, the carriage is returned to its starting position, while the counter measures for another cut. A description of this drive is found in Reliance Bulletin L-2505.

These are two of the many types of cycling operations that utilize Reliance V*S Drives. The variety of Reliance V*S Controls, and the wide horsepower and speed ranges, make these drives applicable to any cycling operation. Cycling is only one operation for which the V*S concept is suited.

If you would like further information on how you can use V*S Drives when designing your product, contact your local Reliance representative, or write to the V*S Product Department. D-1581

RELIANCE ELECTRIC AND ENGINEERING CO.
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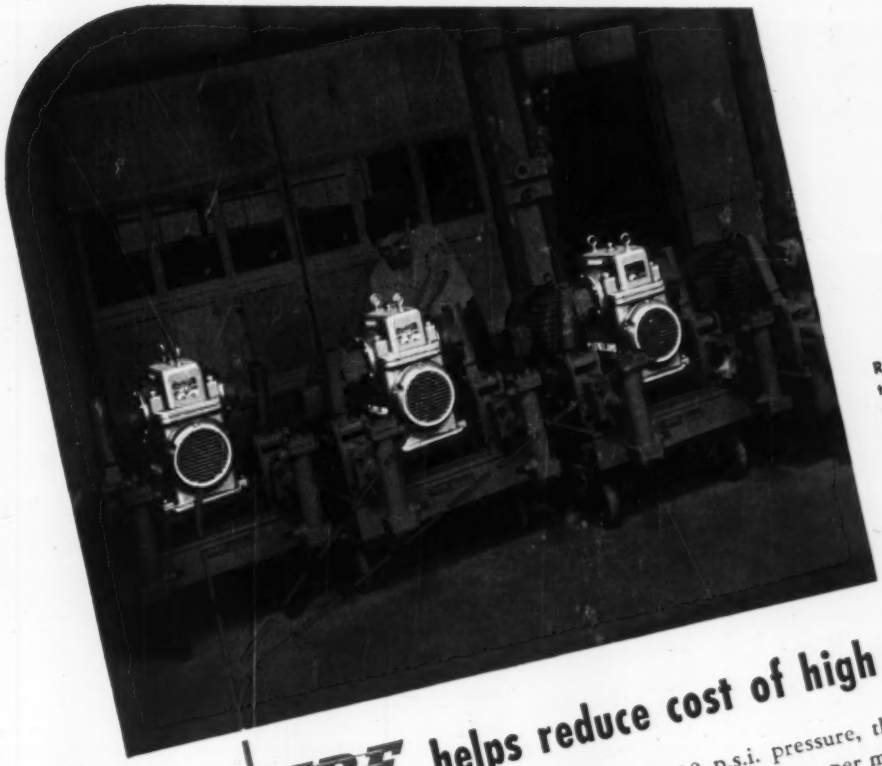


Right off the assembly line, these Philadelphia Pumps are ready for action. Driven by Speedaire . . . these rugged, heavy-duty pumps are assured of a sturdy power source.

SPEEDAIRE helps reduce cost of high pressure pump

DESIGNED to operate at 3,000 p.s.i. pressure, this 50% metal slurry pump delivers 3 gallons per minute. Built to handle tough, unusual jobs, it is driven by a tough, unusual speed reducer—the Cleveland Speedaire. Not only did Speedaire offer the smaller frame size needed for this unit, it also helped substantially to reduce its price. Speedaire costs hundreds of dollars less than a conventional drive of comparable capacity.

Further, the fan-cooled Speedaire worm gear reducer runs cool and smoothly under a heavy load, unaffected by heat, moisture and grime. Thousands are in service. Chances are you can use one or more right now! If you aren't familiar with Speedaire, just call us. Ask for a copy of Catalog 400. The Cleveland Worm and Gear Co., 3287 East 80th St., Cleveland 4, Ohio.

Affiliate: The Farval Corporation, Centralized Systems of Lubrication. In Canada: Peacock Brothers Limited.

CLEVELAND
Worm Gear
Speed Reducers

Circle 402 on Page 19

New CUTLER-HAMMER Synchronous Timers Set the Pace in Industrial Control Timer Design and Performance

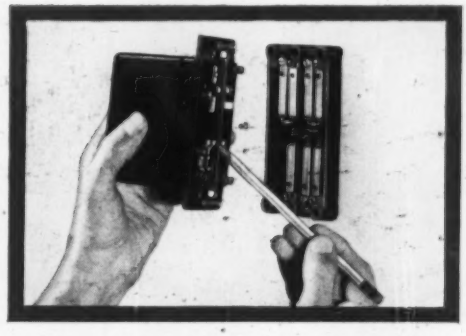
One minute timer:
Adjustable in one second increments, 0 to 60 seconds.
Three minute timer:
Adjustable in three second increments, 0 to 180 seconds.
Five minute timer:
Adjustable in five second intervals, 0 to 300 seconds.

All three timers are dimensionally identical and feature an exclusive combined terminal board and mounting base. This unique design provides more working-room during installation and on-the-job interchangeability of the timing units without disturbing the mounting base or wiring.

The timer dial reads directly in seconds and one glance shows the exact time delay setting. These timers are simple to set too. Just rotate the bronze pointer to the dial position indicating the precise elapsed time desired and the job is done . . . no approximations or tedious readjustments necessary.

The sweep-second pointer counts off the seconds during each timing cycle. Automatic reset returns the pointer to the start position after each cycle or if a power interruption occurs while in operation . . . no undertimed cycles possible.

These synchronous motor driven timers work better and last longer too. Dust, dirt, and atmospheric conditions can't interfere with the timing mechanism. For further information, write today for Bulletin 10336. CUTLER-HAMMER Inc., 1310 St. Paul Avenue, Milwaukee 1, Wisconsin.



The timing unit is removed from the mounting base during installation. Unique spring contacts mate with terminal strips . . . no inter-wiring necessary. The one, three, and five minute timing units are all the same size and easily interchangeable without disturbing mounting base or wiring.

CUTLER-HAMMER
MOTOR CONTROL
C-H

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